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THE BRITISH VETERINARY JOURNAL

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Vol. 115 **September 1959** **No. 9**

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EDITORIAL

THE CONGRESS AT FOLKESTONE

Charles Dickens had a great affection for Kent and he said of Folkestone " The situation is delightful and the air is delicious." If he were to revisit the town in this year of grace he could, and with justice, repeat those words. He would be constrained to add that the place has grown far beyond his most lively expectations and in a manner that was creditable to the succession of people who had nurtured the development and brought it to maturity.

The transition from the modest fishing village of the eighteenth century to the pleasant resort of today has been gradual and so well ordered that the natural amenities of the district have been preserved and enhanced. Nature was kind to Folkestone. It is sheltered from the cold north by hills and on its southern aspect is the sea over which, on a clear day, the eye can be cast on to the coast of France and, on occasion, the Cathedral of Boulogne may come into view. These natural artifices temper the climate which is remarkably equable. It is said that it is rare to have a whole wet day even in winter. Even when it does rain the character of the soil is such that the effects of inclement weather are soon eliminated.

The growth of modern Folkestone may be said to date from the time 1844 when the railway stretched its tentacles to the coast and the great Telford planned and constructed the port. This opened up a new and convenient route to the Continent and brought prestige to the town. The flow of traffic to the Continent reached its acme during the first World War. The port was used by over seven million troops from all parts of the Commonwealth in their journeys to and from the war front in France. Folkestone will rest in the memory of many ex-service men for they took their

first and last steps on "Blighty" soil in the precincts of the harbour. Many who marched down Church Slope to the transports did not return and the road was made part of Folkestone's War Memorial and planted with rosemary bushes, "The Road of Remembrance".

It would be trite to dissertate on the amenities provided for the pleasure and comfort of visitors to Folkestone: the Leas, the Undercliff, the Marine Gardens or Radnor Park. It is sufficient to say that those things which have been designed by the art of man have been blended into the natural decor to such good purpose as to make a complete and harmonious whole. Veterinary surgeons will find record of one of the great occasions in the medical field. William Harvey, physician to James I and Charles I, and the discoverer of the method of circulation of the blood, was born at Folkestone in 1578 in a house near the Town Hall. The memory of this great son of Folkestone is perpetuated by a statue in Langthorne Gardens, by the Harvey Aisle and Window in the Parish Church and by the Harvey Grammar School which was founded by his brother in 1674.

A good Congress should provide for all tastes in the academic and social spheres. No one could exist on a diet of science alone. It would be like swallowing a beef steak in a tabloid form with a consequential loss of the delights of succulence, palate and aroma. To neglect one aspect would dispoil the other. Only the very strong in heart could survive a week of concentrated academic talk. It would appear that the organisers of this Congress at Folkestone are conscious of these things and visitors can look forward to a judicious admixture of social and intellectual fare. There may be some who will remember the N.V.M.A. Jubilee Congress at Folkestone in 1932. The occasion was a great one, 1959 should surpass it.

B.V.A. Annual Congress: Folkestone, August 30th to September 5th 1959

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B.V.A. Annual Congress: Folkestone—August 30th to September 5th, 1959

PROGRAMME

Time	Sunday, August 30th	Monday, August 31st			Tuesday, September 1st			
9.30 a.m.					Radiobiology: The metabolism of iodine and strontium in cows *Author*: Mr. R. J. Garner *Opener*: Mr. N. K. Lloyd	Broiler diseases *Author*: Dr. R. F. Gordon *Opener*: Dr. N. S. Barron		**Ladies' Tour** (Canterbury)
10.00 ,,		**Official Opening of Congress by the Marquess of Abergavenny**						
10.30 ,,		**Opening of Trade Exhibition**						
11.00 ,,								
11.30 ,,		**Congress Group Photograph**						
12 noon		**Annual General Meeting and Presidential Address**			**Plenary Session** The association between intensive farming and livestock disease *Author*: Dr. E. L. Taylor			
12.30 p.m.								
1.00 ,,								
1.30 ,,								
2.00 ,,								
2.30 ,,	**Congress Office Open**	The ecology of the liver fluke *Author*: Dr. C. B. Ollerenshaw *Opener*: Mr. J. E. N. Sloan	Abnormal behaviour in the dog and cat *Author*: Mr. A. N. Worden *Opener*: Mr. W. B. Singleton	**Ladies' Tour** (Dover) — **Pfizers** (first party)	The therapy of parasitic gastro-enteritis in sheep and cattle *Author*: Mr. T. E. Gibson Treatment of debility associated with severe parasitism *Author*: Mr. J. B. White *Opener*: Mr. G. S. Peyton	Diseases of mink *Author*: Mr. K. W. Head Diseases of chinchillas *Author*: Mr. R. Bowden *Opener*: Mr. R. N. Twistleton-Wykeham-Fiennes	**Pfizers** (second party)	
3.00 ,,								
3.30 ,,								
4.00 ,,								
4.30 ,,								
5.00 ,,								
5.30 ,,		**Films**			**Films**			
6.00 ,,	**Church Service**							
8.00 ,,	**Council Meeting**	**Civic Reception**						
8.30 ,,	**Local Divisions' Reception** (9.30 approx.)				**Ladies' Guild Dance**			**Alumnus Dinners**
9.00 ,,								

Time	Wednesday, September 2nd			Thursday, September 3rd			Friday, September 4th		Saturday, Sept. 5th
9.30 a.m.	Some tumours of dogs and cats of comparative veterinary & human interest *Author*: Dr. E. Cotchin *Opener*: Prof. A. Haddow	Blood grouping in domestic animals *Author*: Dr. J. G. Hall *Opener*: Dr. R. F. Goodwin	**Ladies' Dress Show** —Bobby's	Listeriosis: a possible hazard to public health *Authors*: Dr. N. St. G. Hyslop and Mr. A. D. Osborne *Opener*: Dr. N. S. Mair	Differential diagnosis of some conditions of the canine and feline thorax *Authors*: Mr.I.M.Lauder and Mr. D. Lawson *Opener*: Mr. F. G. Startup	**Ladies' Tours** (Dungeness, New Romney and Rye)	Biochemical aspects of diseases of live-stock with particular reference to enzyme systems *Author*: Dr. E. C. Owen *Opener*: Mr. S. L. Hignett	**Ladies' Guild A.G.M.** — **Ladies' Dress Show** —Bobby's	**Adjourned Annual General Meeting and First Meeting of Council 1959/60**
10.00 ,,									
10.30 ,,									
11.00 ,,									
12 noon	Progeny testing *Author*: Prof. J. E. Nichols *Opener*: Dr. J. O. L. King	The sense of taste in domesticated animals *Author*: Dr. F. R. Bell *Opener*: Mr. J. K. D. Dow					Diagnosis and treatment of infertility in the individual cow *Author*: Mr. J. G. Murray *Opener*: Mr. J. A. Pasfield		
11.30 ,,									
12.30 p.m.				**Plenary Session** The principles and practice of the control and eradication of disease *Author*: Mr. J. N. Ritchie					
1.00 ,,									
1.30 ,,									
2.00 ,,									
2.30 ,,	**Visits** **(a) To Canterbury Abattoir** **(b) To Wye College**			**Golf Competition**	**Visit to Martin-Walter Ltd.**		Symposium on Johne's Disease *Diagnosis*: Mr. M. H. Maclay and Mr. N. H. Hole *Incidence*: Dr. F. W. Withers *Vaccination*: Mr. H. N. Spears *Experimental infection*: Dr. J. Deans Rankin *Opener*: Dr. A. Marr	**Pfizers** (third party)	
3.00 ,,									
3.30 ,,									
4.00 ,,									
4.30 ,,									
5.00 ,,				**Films**					
5.30 ,,									
7.30 ,,	(7.30 for 8.00 p.m.) **Annual Banquet**			**Free for Alumnus Dinners, etc.**			**President's Reception**		
8.00 ,,									

THE BLOOD SUPPLY TO THE SKIN OF THE DOG*

H. V. HUGHES, B.V.Sc., M.R.C.V.S., D.V.H., and
J. W. DRANSFIELD, M.V.Sc., M.R.C.V.S.
Department of Veterinary Anatomy, University of Liverpool.

It is an established fact that the condition of the skin is a valuable indication of an animal's general health, and since the well-being of the integument is dependent upon its blood supply it is somewhat surprising that so little attention has been devoted to this important subject by veterinary anatomists. Cutaneous incisions are associated with most surgical interferences, and the extent of vascularity in any area of skin is of some concern to the surgeon. He has to consider the immediate problem of cutaneous haemorrhage and the later questions appertaining to good healing. The close inter-relationship between vessels supplying the deeper structures and those of the overlying skin is also of considerable importance. These are some of the reasons which prompted this inquiry into the origin, course and distribution of the vessels responsible for the supply of blood to the skin.

It should be mentioned that throughout the description which follows the term " skin " is regarded as including not only the epidermis and the corium, but also the superficial layers of the subcutaneous fascia with which the corium insensibly merges.

The investigation was resolved into two distinct parts, viz. the macroscopic and the microscopic study of the arrangements of the vessels. The two parts entailed entirely different techniques, and it is convenient to describe the results in separate sections.

I. Macroscopic Anatomy

It is obvious that some parts of the integument are more vascular than others. The appearance of the lips in some breeds of dogs is evidence of this. In some regions such as the limbs the subcutaneous fascia carries larger and more prominent vessels, particularly veins, than in others. The peculiar localisation which occurs in some forms of dermatitis invites the inquiry whether there may not be some constant pattern in the arrangement of the smaller vessels in the subcutis which is not apparent in the process of routine dissection.

A review of the literature has failed to reveal any complete description of the origin and distribution of the macroscopic vessels concerned with the cutaneous circulation, and on reference to the standard text books on the anatomy of the dog one is at once struck by the very cursory description of such vessels. Veterinary anatomy is not alone in this respect, for works on human anatomy are equally indefinite. Few cutaneous arteries receive specific names, and it is usual to find that an artery is described as giving off " cutaneous branches." Authors of guides to the dissection of the dog, such as Bradley (1948) and Miller (1952) merely mention in their description of certain arteries that branches " become superficial " or " end in the skin." The same can be said of Montané, Bourdelle and Bressou (1953) whose

* Received for publication—December, 1957.

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work deals with the anatomy of the dog and cat on a regional basis. But even in the text books on systematic anatomy of Ellenberger-Baum (1943) and of Sisson (1953) we find in the description of the circulatory system the same vague references to vessels supplying the skin, although in the former work it is stated that the skin is nourished by the artery which supplies the muscle lying immediately beneath. Both these works contain a brief account of the arrangement of the microscopic vessels.

Kulczycki (1889) alone appears to have studied the subject in any detail. This worker enumerated many of the vessels responsible for the supply of blood to the skin of the dog. He stated that the arrangement of the terminal ramifications of the arteries and capillaries within the skin itself was already understood, but the source of the cutaneous vessels had not, so far as he was aware, been studied. He attributed this to the difficulties of technique in the matter of injecting the vessels and identifying the source of cut vessels after removing the skin from the underlying tissues. It may be mentioned that Petit (1929) published an article on the superficial veins of the dog, but this is concerned only with those vessels which are large enough to permit of intravenous injections as a surgical procedure, and no reference is made to the drainage areas of these vessels.

Technique

The work was carried out on a large number of dogs and bitches of various breeds, ages and sizes. In general the dogs were collected from a Dog's Home immediately after they had been destroyed by coal gas poisoning or electrocution. The hair was removed by clipping. It was found that the use of a depilatory offered no advantage over clipping. At first, the whole vascular system was perfused by injecting warm saline solution into one of the common carotid arteries and allowing the fluid to escape from the corresponding external jugular vein until it was relatively clear. Having removed most of the blood from the carcase in this way, the arteries were injected through the same common carotid artery with Indian ink, using a hypodermic syringe. The carcase was then fixed by immersion in 5% formalin. This procedure was carried out on 15 subjects. It was then decided to adapt the same technique for particular regions, using the main artery and vein of the region, e.g. the femoral vessels for the hindlimb, or the deep circumflex iliac vessels for the flank. In avoiding the filling of the heart and large vessels with ink it was found that more uniform pressure was obtained, and better distribution of the injection fluid occurred when it entered the circulatory system relatively near to the area required for examination. Fixation was carried out as before. It will be appreciated that this procedure entailed the examination of many different small regions in numbers of different subjects.

Indian ink was selected as the best agent to use after trials with a number of other materials. Dyes in solution were, of course, ruled out, because they stained the tissues adjacent to the vessels and made the identification of the latter difficult. Gerota's Prussian blue mass was employed but it was discarded because it penetrated the capillaries to such an extent that it produced a uniform blue colouration of the tissues and made identification of the macroscopic vessels difficult. Neoprene latex was used but it possessed no advantages over Indian ink and it did not contrast so effectively with the surrounding tissues.

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In some regions, pieces of skin which had been injected with ink were examined after being made transparent by the classical method of Spalteholz (1893), whereby the material is dehydrated by passing through a series of alcohols and then cleared in xylol.

The Arrangement of the Macroscopic Vessels

To attempt a complete and detailed description of the course and distribution of all the arteries as they have been found running to the skin would, of course, be impossible in an article of this kind.

The following account is based on the examination of a large number of specimens. The vessels were identified either on the deep face of the skin or in the subcutaneous fascia after its removal, and they were traced to their points of emergence from the deeper tissues. In most cases it has been found that the main arterial trunks are accompanied by one or more veins, and only rarely do the veins occupy widely different courses. Anastomosis between branches of arteries bearing different names, and between adjacent branches of any one artery is very extensive and occurs in all areas. It is so extensive that it is quite impossible to say exactly where any one vessel terminates. The sources of these arteries and the courses of their larger primary branches in the subcutaneous fascia are, in general, constant in all dogs. The vessels divide and subdivide into smaller arteries, all running more or less parallel to the surface of the skin, but there is no constancy in the arrangement of the smaller vessels, and no regular pattern common to all dogs. The smallest macroscopic vessels eventually merge into the deep plexus of the microscopic vessels of the corium.

Spalteholz (1927) distinguishes between what he terms simple cutaneous arteries, which reach the skin by running between muscle masses, giving insignificant branches to the muscle tissue, and mixed cutaneous arteries, which run through a more or less thick bed of muscle tissue and give appreciable branches to the muscle fibres before leaving the muscle to nourish the overlying skin. The latter variety of vessel is responsible for a considerable part of the blood supply to the integument and the following is a list of vessels which have been found to fall into this category, together with the area which each artery supplies: —

1. Infra-orbital artery, (*a*) dorsal and lateral nasal branches—the nasal region; (*b*) malar branch—the eyelids.
2. Superior labial artery—the upper lip.
3. Mental artery—the lower lip.
4. Superficial temporal artery—the eyelids.
5. Omo-cervical artery, deltoid branch—the lateral aspect of the neck and arm.
6. Vertebral artery—the dorsal aspect of the neck in its anterior part.
7. Transverse artery of the neck—the dorsal aspect of the neck in its posterior part.
8. Thoraco-dorsal artery—the lateral aspect of the shoulder and thorax.
9. Intercostal and lumbar arteries—the mid-dorsal line and the lateral aspect of the thorax and abdomen.
10. Phrenico-abdominal artery—the flank.
11. Deep circumflex iliac artery—the flank and lateral aspect of the thigh.
12. Internal thoracic artery—the ventral aspect of the thorax.

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13. Axillary artery, pectoral branch—the ventral aspect of the thorax.
14. External thoracic artery—the ventral aspect of the thorax.
15. Cranial epigastric artery—the anterior part of the ventral abdominal wall.
16. Posterior circumflex humeral artery—the lateral aspect of the shoulder and arm.
17. Common, dorsal and volar interosseous arteries—the posterior part of the forearm, laterally and medially (the dorsal interosseous artery also supplies the lateral aspect of the arm).
18. Volar metacarpal arteries—the volar surface of the manus.
19. Cranial gluteal artery—the gluteal region.
20. Lateral circumflex femoral artery—the gluteal region and the area ventral to it.
21. Caudal gluteal artery—the lateral aspect and a small part of the medial aspect of the thigh, dorsally.
22. Posterior femoral artery—the lateral aspect and a small part of the medial aspect of the thigh, ventrally.
23. Femoral artery—the medial aspect of the thigh.

The simple cutaneous arteries which have been observed in the dog are enumerated below with the areas of skin which they supply:—

1. Inferior labial artery—the cheek.
2. Anterior auricular artery—the temporal region.
3. Posterior auricular artery—the ear, the parotid region and the poll.
4. Transverse facial artery—the parotid region.
5. Internal maxillary artery—the parotid region.
6. Cranial thyroid artery—the mandibular space, the cheek and the ventral aspect of the neck in its anterior part.
7. Submental artery—the mandibular space.
8. Ascending cervical artery—the ventral aspect of the neck in its posterior part.
9. Transverse scapular artery—the lateral aspect of the neck in its posterior part and the lateral aspect of the shoulder.
10. External pudendal artery—the lower aspect of the abdomen and the medial aspect of the thigh.
11. Perineal artery—the perineum and the medial aspect of the thigh.
12. Coccygeal arteries—the tail.
13. Collateral ulnar artery—the medial and posterior aspects of the forearm in its upper part.
14. Proximal collateral radial artery—the lateral and anterior aspects of the forearm and the dorsal aspect of the manus.
15. Saphenous artery—the medial aspect of the thigh in its lower part, the medial aspect of the leg, and the dorsal and plantar aspects of the pes.
16. Anterior tibial artery—the lateral aspect of the leg and the anterior aspect of the tarsus.

Whilst the points of superficial emergence of the larger cutaneous arteries of the thorax and abdomen clearly suggest that their arrangement is associated with the segmentation of the body, this segmental arrangement of the blood vessels is much less regular than in the case of the nerves, for not only do the macroscopic vessels

anastomose extensively with one another but it is not uncommon to find that a primary, constant branch is considerably larger than its immediate neighbour whose function it may be said to have taken over. (For further discussion of this subject the reader is referred to the work of Grosser (1905).)

The plexuses which are formed in the subcutaneous fascia vary in the sizes of the areas enclosed by their macroscopic meshworks but they are especially evident, as might be expected, over bony prominences, e.g. the point of the elbow, where the distance between the vessels forming the plexus is very small. Similar rich plexuses, with, however, a greater distance between the branches of the network, are present over large muscle masses, e.g. the triceps brachii and the biceps femoris.

Discussion

It would appear that there is nothing in the arrangement of the macroscopic vessels which can be held to account for the localisation observed in some of the various forms of dermatitis, but it is significant that certain vessels reach the skin by passing through a comparatively thick mass of muscle tissue (the mixed cutaneous vessels to which reference has been made). It is possible that this variety of vessel may be influenced by the mechanical action of the muscle through which it runs, and it may also be that under certain circumstances the muscular supply is increased at the expense of the cutaneous supply. Of course, the extensive plexuses of anastomosing vessels, including those which are microscopic, will provide an adequate cutaneous blood supply in the event of any temporary reduction in the flow through any one vessel, although these may not be sufficient to counteract a permanently reduced blood flow.

Mention has been made of the extensive macroscopic plexuses over bony and muscular prominences, and it is reasonable to assume that these developments are associated with the pressure to which the skin over such prominences is subjected when the animal is reclining in its various natural postures.

II. Microscopic Anatomy

It appears that Tomsa (1873) was amongst the first to investigate the minute vessels in the skin of the human subject, thus laying the foundations for a study of this kind. So far as it has been possible to determine, it is to Stirling (1875) that credit is due for having first studied the arrangement of these vessels in the skin of the dog, although his investigations appear to have been somewhat incomplete. Spalteholz (1893, 1927) will, however, always rank as the most outstanding worker in this field of histology. Much of his work remains as authoritative today as it was when it was first published, and although mainly concerned with the human subject, some of his early investigations were carried out on the dog. Trautmann and Fiebiger (1949), in their text book dealing with the histology of the domestic animals, refer to the blood vessels in their description of the skin, but the subject is treated in a general manner, and little mention is made of special features present in different parts of the body. The same may be said for the treatment of the subject in the standard text books of Ellenberger-Baum (1943) and Sisson (1953) already mentioned.

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Technique

The method employed in the study of what might be termed the microscopic blood vessels of the integument has consisted of (a) the examination of areas of skin under a dissecting microscope using the conventional magnifications, and (b) the examination of sections made from small pieces of skin from various regions of the body.

(a) In the first case, pieces of skin were taken from a dog which had been bled and whose vessels had been injected with Indian ink. The skin was either examined immediately after removal from the body, or cleared by passing through alcohols into xylol, according to the method of Spalteholz (1893).

(b) For study under higher powers of magnification, pieces of skin, usually about 10mm square, were embedded in paraffin wax, and serial sections were cut (1) more or less vertically, i.e. in the direction of the length of the hairs, and (2) horizontally, i.e. parallel to the surface. Sections were cut at varying thicknesses; for general purposes at 100μ, but occasionally considerably thinner (about 8μ). The sections were stained by haematoxylin and eosin.

The Arrangement of the Microscopic Vessels

With certain exceptions, e.g. the nostril, lip, eyelid, ear, nipple, prepuce, anus, vulva and foot pad, which will be dealt with individually later, the skin throughout the body shows a common plan in the matter of the arrangement of the microscopic blood vessels.

The blood is carried to the corium of the skin by branches of the macroscopic vessels previously described. These vessels, naturally, become progressively smaller as they approach the surface of the skin, and the dividing line between what is regarded as a macroscopic vessel and one that is microscopic must necessarily be quite arbitrary. It is possible to recognise three distinct arterial plexuses, all lying parallel to the surface. These are designated as deep, middle and superficial.

1. The deep plexus or subcutaneous plexus (representing the fascial and subcutaneous plexuses of Spalteholz). This is formed from the smallest vessels described in Section I, many of which can, in an injected specimen, be appreciated with the naked eye. It consists of vessels running in the superficial parts of the subcutaneous fatty and areolar tissue and on the deep face of the dermis. Where there is a layer of cutaneous muscle the vessels lie both superficially and deeply to the muscle, the former layer being reinforced by branches passing through the muscle. In the muscle itself the vessels are found to run along the length of the bundles of fibres with intercommunicating branches here and there. The plexus may be arranged in more than one layer. From this plexus branches pass superficially through the loose connective tissue fibres and the fat in the direction of the hairs. Some enter the hair bulb, where they form capillary loops; others pass upwards along the length of the hair or hairs, where these are in groups, supplying the adjacent part of the hair follicle by means of a capillary network around it. A similar network occurs in the region of the tubular glands and the deeper parts of the ducts, and the arrectores pilorum muscles. Other larger branches run directly upwards as the radicles of the middle plexus.

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2. The middle layer plexus (the cutaneous plexus of Spalteholz). This plexus is situated immediately below, or at the level of, the sebaceous glands. The plexus is fed from below by the vessels previously mentioned as ascending from the deep plexus, and from this middle plexus, usually at the same point, smaller vessels run towards the surface to form the third or superficial plexus. Branches from the plexus descend to reinforce the capillary networks surrounding the hair follicles, the ducts of the tubular glands and the arrectores pilorum. Ascending vessels continue the supply of the follicles and the ducts of the tubular glands, and they also form plexuses around the sebaceous glands. Since the distribution of the hair follicles and their associated structures varies in different parts of the body it is obvious that this plexus will show modifications in its position and development.

3. The superficial layer plexus (or subpapillary plexus of Spalteholz). This lies in the outer layers of the corium and is formed by the union of small vessels ascending from the middle plexus below. In those areas where the papillary body is well developed a rich supply of capillary loops runs from the plexus into it. In the regions where the papillae are poorly developed the loops are correspondingly few, and where they are absent the plexus has the form of a flattened capillary meshwork without loops.

In general, the veins and arteries follow one another quite closely, although, here and there, there may be some divergence of their courses. The veins, as might be expected, are slightly larger than the arteries. A superficial venous plexus, corresponding with the arterial plexus, receives blood from the capillary loops of the papillary body, and from this plexus veins pass deeply, draining into vessels arranged as middle and deep plexuses, which are similar in position to the previously described arterial plexuses.

The above is a statement of the general pattern of the arrangement of the microscopic vessels of the skin covering the greater part of the body. Sample sections of the integument were taken from many different regions of the body. These included areas in the mid-dorsal and mid-ventral lines of the head, neck, thorax, abdomen and tail, and regions of the limbs such as the lateral aspect of the shoulder, the medial and lateral aspects of the forearm, the thigh and leg, the points of the elbow and hock, and the interdigital spaces. In all these areas there is a definite similarity in the general microscopic pattern of the vessels, but certain differences, dependent upon the varying histological structure, were apparent.

In the mid-dorsal line of the body throughout its length the three layer plexuses are all well developed, the connecting branches following the direction of the hairs. Papillary loops are inconspicuous. The development of the vessels is associated with the density of the hairs (which are long), the large arrector muscles and sebaceous and tubular glands. In this connection it may be mentioned that the sebaceous glands are very well developed at the root of the tail. At the tip of the tail the hairs and associated glands are arranged so closely to one another that the vascular supply appears very rich. Papillary loops, although present, are very few in number. Arterio-venous anastomoses have been observed in the deeper layers.

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In places where there are bony prominences, such as the points of the elbow, stifle and hock, the deep layer plexus is always in the form of a close-meshed network. Papillary loops are insignificant.

In such areas as the under aspect of the head, neck and thorax, and on the lateral aspect of the thorax and abdomen, where the skin is thinner than in the preceding regions, the hair follicle complexes are less densely arranged and consequently the plexuses are not quite so rich.

In the folds of skin separating the digits, on both their dorsal and ventral aspects, the usual arrangement pertains, apart from the fact that there is a marked obliquity in the course of the vessels connecting the plexuses, especially on the dorsal aspect, this obliquity corresponding with the inclination of the hairs of the region.

The skin of the medial aspect of the thigh and of the axilla is thin, and the blood supply is less copious than in the preceding areas.

Apart from some of the special regions to be described later, the ventral abdominal wall shows the smallest proportion of hair follicle complexes, these being widely separated from one another. The papillary layer of the dermis is well defined, and the capillary loops of the superficial plexus are correspondingly prominent. The middle plexus gives many branches to the large sebaceous glands which are present in this region. The skin of the upper part of the scrotum resembles that of the ventral abdominal wall, but in the distal part of the sac there are fewer and very much shorter hairs. Well developed capillary loops arise from the superficial arterial plexus to supply the papillae of the dermis in this region. The deep and middle plexuses lie in the dartos muscle and give branches to it.

The Blood Vessels of the Special Areas

Most of the remaining special areas of the skin occur at muco-cutaneous junctions, i.e. around natural orifices. But before these are described the arrangement in the external ear, the foot pad and the nipple must be mentioned.

The external ear. The skin on the external (superficial) surface of the ear flap shows a close resemblance to that of the adjacent parts and has the usual arrangement of blood vessels. The deep plexus lies close to the cartilage, and branches from this pass through foramina to reach the deep (internal) surface of the ear flap. (Many of these vessels are of macroscopic size.) On the internal surface of the ear flap these vessels combine to form a deep plexus for this surface. In some parts the middle plexus is present, but in others this does not appear as a separate entity, for here the skin is very thin and is intimately attached to the perichondrium. Where the middle plexus is present it lies below the level of the hair bulbs, the hairs being very short. The superficial plexus shows a few capillary loops. Towards the border of the ear flap the skin of the internal surface shows many more hairs than in its central part and its structure resembles that of the skin of the external surface. At the extreme border the hair is very dense and the vessels of the deep plexus are prominent. Arterio-venous anastomoses have been observed in the deep layer plexus scattered throughout the whole of the skin of the ear flap.

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The skin lining the deep part of the ear canal shows some resemblance in structure to that of the internal surface of the ear flap, but the hairs are fewer, smaller and shorter. The deep plexus lies on the cartilage beneath the masses of fat which help to form the prominences of the ear canal, and vessels pass through the fat, giving branches to this and continuing upwards to feed the middle plexus. This lies superficially to the fat but deep to the hair bulbs and tubular glands. Few surface capillary loops are present.

The foot pad. The vessels of the deep plexus lie below the fat and fibro-elastic tissue which make up the main mass of the pad. From the plexus vessels run to this tissue and form capillary plexuses around the peculiar merocrine glands contained therein. Other branches pass through the tissue to form the middle plexus, which lies superficially to the fatty tissue. From this plexus some branches pass deeply to the glands and others run towards the surface to form the superficial plexus. This latter gives origin to capillary loops which run into the well-developed papillary body, and many of these loops subdivide.

The nipple. From the deep plexus of the skin adjacent to the base of the nipple a circular vessel (which is apparent macroscopically) is formed which surrounds all the teat canals at this level. From it numerous minute vessels (3 or 4 for each canal) run towards the apex of the nipple accompanying the canals, and branches from these are detached at intervals to form circular vessels around each canal. From the latter capillary loops arise to run to the papillary body of the canal. In addition, branches run from the more peripherally situated vessels towards the surface, supplying the few hairs and glands of the region. A superficial plexus is present which gives capillary loops to the surface papillary body. An open meshwork in the corium situated superficially to the canals replaces the middle plexus of other regions. The arterial and venous plexuses are extensive, as would be expected, bearing in mind the erectile nature of the nipple, and the veins finally drain into a large circular vein surrounding the base of the nipple. The deep plexus gives branches to the more superficial acini of the gland.

The Muco-cutaneous Junctions

In these regions, which occur at the natural orifices, there is a transition from the integument, with its hairs and glands, to the cutaneous mucous membrane, with its stratified epithelium lining the adjacent part of the cavity concerned. In general, there is a corresponding transition in the arrangement of the blood vessels from the three plexuses (superficial, middle and deep) present in the skin to a much less regular open meshwork of vessels in the mucous membrane, with only occasional traces of the three layer plexuses. In most cases the junction shows a ring of very much enlarged sebaceous glands, sometimes considerably modified, which may or may not be associated with hairs.

The eyelid. Although it might be objected that the eyelids do not strictly surround a natural orifice, the structure of the region where the skin merges with the conjunctiva is so similar to that occurring at muco-cutaneous junctions that it will be considered at this point.

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The skin of the eyelid shows the usual three plexuses and their connecting branches. There are relatively few dermal papillae and the capillary loops are correspondingly small in number. In the region of the transition to conjunctiva the hairs disappear, papillae become more evident, though smaller, and the openings of the tarsal glands are seen. The blood vessels now form a meshwork with no regular arrangement as three plexuses, although there is frequently a clear indication of a superficial plexus giving loops to the papillae of the conjunctiva. The parent vessels of this meshwork lie superficially to the tarsal glands but deep to the orbicularis oculi muscle.

The lip. This is a very vascular region. Whilst in the case of the upper lip the transition from skin to mucous membrane takes place close to its border, in the lower lip this occurs some distance below the border on its external surface, a considerable area of this surface being covered by mucous membrane. The usual three plexuses supply the essential cutaneous structures. The roots of the large tactile hairs here, as elsewhere, are particularly well furnished with blood vessels. A large vein in the form of a blood sinus surrounds the outer root sheath of these hairs.

In the cutaneous mucous membrane of the lip the stratified epithelium lies on an extensive papillary body. The vessels usually form a superficial plexus giving capillary loops into this, the plexus being supplied by a meshwork in which there may be layers suggestive of middle and deep plexuses. In general, the larger vessels lie on the oral surface of the orbicularis muscle, many branches running superficially through the muscle.

The region of the nostril. The planum nasale, being devoid of hairs and glands, has its moistness maintained by the lateral nasal gland. The integument, external and internal to the opening of the nostril, shows a papillary body richly supplied with capillary loops furnished by the superficial plexus. As is the case in the cutaneous mucous membranes already described, there are indications of a deep plexus connected by a meshwork with this superficial plexus, and there may even be occasional traces of a middle plexus.

The prepuce. The blood vessels in the skin of the exterior of the prepuce are arranged in the customary three layers of plexuses, the superficial plexus supplying many loops (some of which are double or treble) to the papillary body. There is a very rich blood supply to the well-developed hairs and the prominent sebaceous glands in the region of the preputial orifice. Within the orifice there is a transitional region where hairs are absent but large tubular glands occur. This is followed by a glandless area, extending as far as the urethral opening, which shows a well-marked papillary body. The vascular supply is rich and is arranged as in the cutaneous mucous membranes already described. The vessels of the plexuses are very large, particularly the veins.

The vulva. The skin on the exterior of the labia of the vulva contains a moderate number of hair follicle complexes with their associated glands. The tubular glands are well below the level of the hair bulbs, and consequently the deep plexus, from which they derive their blood, lies some distance from the hair bulbs. The middle

and superficial plexuses are apparent, the latter giving loops to the few overlying papillae. Towards the margin of the fissure the hairs become single and their sebaceous glands are very large. On the margin itself the hairs disappear, the area of modified skin passing on to the internal surface of the labia to merge with the cutaneous mucous membrane. This intermediate hairless area of skin has large convoluted tubular glands and sebaceous glands. Here and in the adjacent mucous membrane the superficial plexus is present giving a few loops to the small papillae of the surface lining. The middle plexus is evident, while the deep plexus takes the form of branches radiating from the central tissue of the labia.

The anus. In the periphery of the zona cutanea a fairly close arrangement of hair follicle complexes is present with large sebaceous glands and rather straight tubular glands, and here the usual three plexuses occur. Towards the anal orifice the hairs gradually disappear, single hairs at first replacing the complexes, and around the actual orifice there is a broad zone of hairless skin in which lie the so-called circum-anal glands. The most peripheral of these are adjacent to the most central of the hair follicle complexes and the follicles of the single hairs which replace them centrally. The blood supply of the hairless area is rather sparse and is in the form of the open meshwork characteristic of the cutaneous mucous membranes. The zona intermedia is, of course, hairless, and there is a very rich blood supply to the numerous tubular and sebaceous glands contained therein. The vascular meshwork typical of cutaneous mucous membranes is present. The blood supply of the wall of the anal sac is less copious than that the zona intermedia. Here, again, the modified tubular glands lying in its wall derive their blood from vessels arranged as an open meshwork.

Discussion

The investigation has demonstrated the essential features of the arrangement of the microscopic blood vessels in the skin of the dog. The findings are, in a large measure, in agreement with those of Spalteholz (1893, 1927), and they confirm his contention that there is in general throughout the skin of the body a basic pattern in the minute architecture of the blood vascular system. Deviations from this pattern have been observed, but it is felt that, except in the case of what have been described as "special areas" they do not merit particular attention. It has been found, too, that the findings have much in common with those of Goodall and Yang (1954) in their study of the skin of the Ayrshire calf. It should be mentioned, however, that these workers were concerned only with the skin of the back and flank, and they make no reference to the arrangement of vessels in the relatively hairless areas of the skin.

In the regions of the body where the skin is covered by hair, three horizontally arranged arterial and venous plexuses, superficial, middle and deep, are constantly present (the deep plexus may be arranged in more than one layer). Since, however, the papillary body is very poorly developed or absent where hair abounds, the capillary loops projecting into these papillae from the superficial plexus are not prominent. In the hairless areas (except in the digital pads, where the three plexuses are present) these plexuses are replaced by an open meshwork of vessels less regularly arranged. It must be pointed out, however, that in the hairless areas a superficial plexus is always recognisable, from which are derived the capillary loops which supply

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the more or less well developed papillary body of such a region. Spalteholz carried out much of his work on the balls of the fingers and toes and similar areas of the human body where a papillary body is marked, and his description would appear to over-emphasise this structure and its capillary loops. In the dog, apart from the foot pads and the cutaneous mucous membranes, the loops are not prominent features.

Arterio-venous anastomoses have been observed in the deeper layers in the ear flap and the free extremity of the tail.

The very extensive microscopic plexuses of the vessels in the skin would appear to ensure a complete and continuous supply of blood to the skin under all circumstances, including the temporary blockage of any of the main vessels running from the deeper layers. But apart from this nothing in the arrangement of the vessels themselves has been found to account for the localisation which occurs in various pathological lesions appearing in the skin. May it be that the explanation lies in the distribution of the nerves running to the vessel walls?

Summary

The blood supply to the skin of the dog is described from both the macroscopic and microscopic aspects, and the significance of some of the findings is discussed.

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BOTRYOMYCOSIS OF THE UDDER

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It has been reported by Tanner (1952) that the incidence of botryomycosis of the udder appears to be increasing in Sweden. A description is given here of some detailed histopathological examinations that have been made of the udders of cows cast from the Hannah Institute herd. A relatively high incidence of this condition was observed and it is therefore possible that botryomycosis of the udder is more common in this country than is realised.

Methods and Materials

The udders were taken from 45 cows cast from the Institute herd during the past seven years. The udders were examined by the method described by McFarlane, Blackburn, Malcolm & Wilson (1949) and Blackburn (1952) in which the frozen udder is subjected to multiple horizontal slicing. Four or five blocks of tissue for histological examination were taken from each of three levels in each of the four quarters of the udder. Sections cut from these blocks of tissue were considered as representing the region from which they were taken and thus it was possible to give a rough estimate of the extent of any lesions in the affected quarters.

Milk samples were taken from each quarter of every cow in milk in the herd at weekly or fortnightly intervals. Bacteriological examination and total and differential cell counts were done on each sample by the methods described by Blackburn (1956), Blackburn & Macadam (1954) and Blackburn, Laing & Malcolm (1955).

A course of antibiotic treatment consisted of the injection via the teat canal of dihydrostreptomycin (0.25 g.) on three consecutive days. Occasionally dihydrostreptomycin (0.1 g.) and penicillin (1,000,000 units) were used instead.

Results

Lesions of botryomycosis were found in seven of the 45 udders examined (15.6%). Of 180 quarters a total of ten were found to be affected with this condition (5.6%). The extent of the lesions is shown in Table 1. It was estimated that 32% of one quarter (Daisy LF) was affected with lesions of botryomycosis. The extent of the lesions in the remaining nine quarters varied from 0.5 to 8.0%. The lesions in two of the quarters were easily visible to the naked eye; in two quarters they were seen on careful examination after multiple slicing, whilst in the remaining six quarters they were seen only on microscopic examination. A bacteriological examination was done on only one lesion and this was in the left-hind quarter of the cow Gadfly. A pure culture of coagulase-positive *Staphylococcus aureus* was obtained.

The lesions were the typical granulomata of botryomycosis with gram-positive cocci contained in an amorphous mass of eosinophylic substance (Figure 1). This mass was surrounded by a zone of polymorphs around which were endothelioid cells, again surrounded by granulation tissue. Around the lesion was a layer of fibrous tissue. This layer was thin around the small lesions but thicker around the larger ones. The larger lesions were multifocal with three or more masses of eosinophylic material

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TABLE 1

Cow	*Quarter*	*Percentage of the tissue of each quarter found to be affected*	*Lactation number*	*Number of samples examined*	*Average total cell count (in millions*	*Range of total Cell counts of cells/ml.)*	*No. of samples in which polymorphs amounted to more than 60% of the cell count*	*No. of samples with coagulase-positive staphylococci*	*No. of times treatment was applied*
Griselda	LH	2	8	8	1.19	0.63- 4.60	0	Not examined	0
Jennifer	RF	3	9	16	5.15	0.43- 45.40	16	0	1
Daisy	LF	32	5	16	11.19	2.25- 43.60	16	15	1
			6	20	16.92	3.10-164.80	10	8	2
				Total 36	Mean 14.05	2.25-164.80	Total 26	Total 23	Total 3
Dixie	LH	2	4	34	6.28	0.47- 43.60	25	17	6
			5	not milked					
Dixie	RH	6	4	34	2.63	0.07- 16.00	23	11	5
			5	18	3.44	0.42- 7.80	13	8	1
				Total 52	Mean 3.03	0.07- 16.00	Total 36	Total 19	Total 6
			3	18	0.52	0.10- 1.52	10	1	0
			4	40	0.41	nil - 1.96	12	0	1
Stella	LH	2	5	20	1.38	nil - 7.80	6	10	3
			6	17	0.88	0.01- 3.25	9	8	4
			7	15	0.83	nil - 4.86	8	10	3
				Total 110	Mean 0.80	nil - 7.80	Total 45	Total 29	Total 11
			3	18	2.77	0.22- 13.20	7	12	2
			4	40	0.07	nil - 0.74	4	7	1
Stella	RH	0.5	5	20	0.38	nil - 0.98	13	0	0
			6	17	1.58	nil - 18.20	9	5	2
			7	15	1.49	0.01- 2.94	7	15	3
				Total 110	Mean 1.26	nil - 18.20	Total 40	Total 39	Total 8
Alice	RH	2	7	18	0.92	0.70- 2.60	4	1	1
			8	15	6.39	1.36- 17.00	8	7	0
				Total 33	Mean 3.66	0.70- 17.00	Total 12	Total 8	Total 1
			4	43	0.67	0.10- 3.00	18	19	3
			5	30	1.66	nil - 9.10	16	13	4
Gadfly	LF	2	6	21	2.06	nil - 13.80	11	10	5
			7	20	2.19	nil - 17.00	7	6	4
			8	19	1.85	0.05- 9.50	11	1	2
			9	16	5.89	0.02- 26.40	13	16	0
				Total 149	Mean 2.39	nil - 26.40	Total 76	Total 65	Total 18
			4	43	0.92	0.02- 8.40	19	11	2
			5	30	1.18	nil - 6.40	17	5	3
Gadfly	LH	8	6	21	1.36	0.01- 9.20	13	2	3
			7	20	1.91	0.01- 26.00	8	6	2
			8	19	1.71	0.03- 12.40	12	12	3
			9	16	3.68	0.29- 12.00	15	11	1
				Total 149	Mean 1.79	nil - 26.00	Total 84	Total 47	Total 14

present, each with its own zones of polymorphs, endothelioid cells and granulation tissue. The endothelioid cells were less in evidence in the larger lesions. There was not the same tendency for club formation of the masses of eosinophylic substance as is seen in lesions of actinomycosis. In one lesion there were gram-positive cocci outside the amorphous mass, and because they were all around it, it is unlikely that they had been carried there by the microtome knife in the process of section cutting. A detailed examination was made of the supra-mammary lymph nodes of the 45 udders and no lesions of botryomycosis were found.

Table 1 shows in condensed form the results of the examinations of the milk samples taken from the affected quarters of the seven cows. Two of the cows concerned, Griselda and Jennifer, were slaughtered when milk samples had been examined for only part of one lactation. Milk from the affected quarter of each animal did not show coagulase-positive staphylococci. The other five cows showed, for one or more lactations, repeated infection with coagulase-positive staphylococci in the quarter or quarters affected. The infection was associated, as a rule, with subclinical mastitis as shown by the differential cell count which gave a high cell count, a high proportion of the cells being polymorphs. Milk from the left-fore quarter of the cow Daisy was examined for two lactations and all samples had high cell counts. Of the 36 samples examined, 26 had polymorph percentages of over 60 and coagulase-positive staphylococci were present in 23. Three courses of intramammary antibiotic treatment were given and after one of them staphylococci were not found in the milk for three weeks. Milk from the left-hind quarter of the cow Dixie was examined only during the fourth lactation because during the 5th lactation the quarter was not milked. The 34 samples examined had high to very high cell counts, 25 of them having a polymorph percentage of over 60, and from 17 samples coagulase-positive staphylococci were recovered. Six courses of treatment were applied and after three of these staphylococci were not recovered for periods of 2 to 5 weeks. Milk from the right-hind quarter of the cow Dixie was examined for two lactations and of the 52 samples examined, 36 had high polymorph percentages and 19 of them coagulase-positive staphylococci were recovered. Six courses of treatment were applied and after four of these, staphylococci were not recovered for periods of from 2 to 5 weeks. Milk from the right-hind quarter of the cow Alice had high to very high cell counts for two lactations although only 12 of the 35 samples showed a high percentage of polymorphs. In the seventh lactation coagulase-positive staphylococci were found on one occasion and after a course of treatment these organisms were not recovered again in that lactation. In the eighth lactation coagulase-positive staphylococci were recovered from the last seven samples examined. Treatment was not given.

The cows Stella and Gadfly each had two quarters affected with botryomycosis and milk samples were examined for a much longer period than in any of the other affected cows. Milk from the cow Stella was examined from the third to the seventh lactation. In the third lactation coagulase-positive staphylococci were recovered from the left-hind quarter only once and not at all in the fourth lactation. During the next three lactations it was recovered from 28 of 52 samples. Three courses of treatment were given in the fifth lactation and after one of them staphylococci were not recovered from the milk for a period of 6 weeks. Four courses of treatment were

given in the sixth lactation and the last of them cleared the staphylococcal infection for 16 weeks. Similarly in the seventh lactation the last of three courses of treatment cleared infection with staphylococci for 14 weeks. Milk from the right-hind quarter of the cow Stella was found to be infected with coagulase-positive staphylococci for three months when this cow was first sampled. Two courses of treatment cleared the infection. The first seven samples taken in the next lactation were infected but one course of treatment cleared the infection for the remainder of the lactation and for the whole of the next lactation. In the sixth lactation treatment cleared infection for ten weeks, but when the quarter became reinfected treatment did not clear the infection. Every sample examined in the seventh lactation was found to be infected and three courses of treatment had no effect.

Milk from the cow Gadfly was examined from the fourth to the ninth lactation. The left-fore quarter was given three courses of treatment in the fourth lactation and these treatments cleared infection with coagulase-positive staphylococci for periods of 5 weeks, 3 weeks and 12 weeks. Similarly in the fifth lactation four courses of treatment cleared infection for periods of 8 weeks, 3 weeks, 4 weeks and 4 weeks. In the sixth lactation five courses of treatment were given and three of these cleared infection with coagulase-positive staphylococci for periods of 12 weeks, 4 weeks and 6 weeks. In the seventh lactation two of the four courses of treatment cleared infection for periods of 16 weeks and 4 weeks. The last two milk samples examined in the seventh lactation contained coagulase-negative staphylococci and this infection continued throughout the eighth lactation in spite of a course of treatment, until the final sample from which coagulase-positive staphylococci were cultured. In the ninth lactation coagulase-positive staphylococci were isolated from every sample. Treatment was not attempted. Treatment of the left-hind quarter of the cow Gadfly given in the fourth to the seventh lactations cleared infection with coagulase-positive staphylococci for periods ranging from 4 to 12 weeks, but in the eighth and ninth lactations treatment was unsuccessful.

It will be seen that, in the earlier lactations at least, treatment was, as a rule, successful in controlling infection of the milk with coagulase-positive staphylococci, reinfection however occurred after varying periods of time. In later lactations there was a tendency for treatment to be less successful although the organisms were sensitive *in vitro* to streptomycin.

Discussion

Much confusion has arisen because the lesion referred to as botryomycosis in the horse is often referred to as actinomycosis in other animals. Davies & Torrance (1930) state that *Staphylococcus pyogenes* is apparently responsible for all cases of udder actinomycosis in cows, and Fennestad, Pederson & Moller (1955) refer to the so-called actinomycosis in pigs caused by *Staph. pyogenes*. Tanner (1952) refers to botryomycosis as chronic staphylococcal mastitis having the appearance of actinomycosis. Botryomycosis in man is discussed by Berger, Vallée & Vézina (1936) who consider that the term is misleading and suggest that it should be replaced by the term staphylococcic actinophytosis. Even though the term botryomycosis may not be satisfactory it has been used for so long in veterinary literature to describe this particular type of lesion associated with gram-positive cocci that it would be confusing to change it.

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Magrou quoted by Berger *et al.* (1936) showed that *Staphylococcus aureus* is able to form granules similar to those of actinomycosis and that the ability of the organism to do this depends on closely allied biological conditions. An equilibrium between the organisms and the tissues, depending primarily on the quantity introduced, appears to be necessary for the development of the botryomycotic lesion. Lemoine (1938), however, failed to produce lesions of botryomycosis in rabbits using virulent human staphylococci. A case of botryomycosis in soft tissue in man in which a piece of bristle was found in the lesion was reported by Plaut (1937), and Kimmerstiel & Oden (1939) have described two cases of intra-abdominal granulomata in man, one of which was characteristic of botryomycosis. The lesions in both cases contained a fish bone. Kimmerstiel & Easley (1940) failed to produce botryomycosis by passing infected horse hairs through the testes of guinea-pigs or by injecting staphylococci into foreign body granulation tissue produced in rats by the use of talcum powder. Infected fish bones implanted in the peritoneal cavity of rabbits did not produce the condition, but sterile or contaminated fish bones pierced through the wall of the intestine of rabbits and fixed against the peritoneum with the pointed end freely movable in the lumen did produce botryomycosis. Kimmerstiel & Easley concluded that a continuous invasion of the tissues by staphylococci is necessary to produce the condition, and that a foreign body, such as a fish bone penetrating the intestine is a method of perpetuating the infection. In a bovine udder continually infected in the milk with staphylococci this state of affairs is to some extent reproduced. The udder may be considered to act, so to speak, as a continuous culture system if the milk is infected with a particular organism over a long period. The organisms multiply during the periods between milking and their numbers are greatly reduced when the cow is milked. If the milk is infected with staphylococci it is possible that the udder tissues may be subjected to a continuous invasion by small numbers of the organisms with the result that lesions of botryomycosis may occur.

The question arises as to whether the presence of the lesions of botryomycosis in the udder may cause the milk to become reinfected with staphylococci. It is possible that the organisms can break out of the amorphous mass of eosinophylic substance, as was observed in one lesion. It is also probable that the granulomata of botryomycosis form within the duct system of the udder and that a potential opening to this system may remain in the fibrous capsule of the lesion. It is thus possible that staphylococci from a lesion of botryomycosis may escape from the lesion to reinfect the milk.

A further question is whether botryomycosis of the udder is becoming more common. During the 10 years from 1942 to 1951 more than 300 udders from various sources were examined by the present author using methods similar to that employed in the present work, and only one udder was seen to be affected with botryomycosis, whereas during the years 1952 to 1958 seven out of 45 udders examined were found to be affected. It must be noted, however, that the 45 udders in this later work came from one herd so that it cannot be concluded with certainty that there has been a general increase in the condition. There is a possibility that the condition is even more common than the present work indicates because in the method used for examination of the udder an isolated lesion could be missed. Although fifteen blocks

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of tissue were taken from each quarter, this represents only a small proportion of the udder tissue. According to Tanner (1952) who made a study of 144 udders which to naked-eye appearance had actinomycotic lesions, botryomycosis appears to be increasing in Sweden.

If there has been an increase of this condition it may have resulted from the use of antibiotics in the treatment of mastitis. This may have occurred in two ways: (1) reduction of the incidence of streptococcal mastitis giving staphylococci a freer field, or (2) the antibiotics themselves may assist in giving the closely limited biological conditions that appear to be necessary for the lesions to form.

Summary

(1) Lesions of botryomycosis were found in seven of 45 udders taken from cows cast from the Hannah Institute herd in a period of seven years. A total of ten quarters were affected.

(2) The lesions were the typical granulomata of botryomycosis with gram-positive cocci contained in an amorphous mass of eosinophylic substance.

(3) Milk samples were examined at regular intervals up to the time of slaughter. Five of the cows showed for one or more lactations repeated infection of the milk with coagulase-positive staphylococci in the quarter or quarters affected.

(4) Intramammary treatment with dihydrostreptomycin in the earlier lactations was, as a rule, successful in controlling infection of the milk with coagulase-positive staphylococci, but reinfection occurred after varying periods of time. In later lactations treatment tended to be less successful although the organisms were sensitive *in vitro* to the antibiotic.

(5) The literature on the experimental production of botryomycosis is reviewed. It is suggested that the closely limited biological conditions that appear to be necessary for lesions to form are likely to occur in an udder repeatedly infected with staphylococci.

(6) The question of whether lesions of botryomycosis in the udder may cause the milk to become reinfected with staphylococci is discussed.

(7) Evidence is presented to show that there has been an increase in the incidence of this condition, and the possibility that the use of antibiotics in the treatment of mastitis is responsible for the increase is discussed.

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PLATE 1

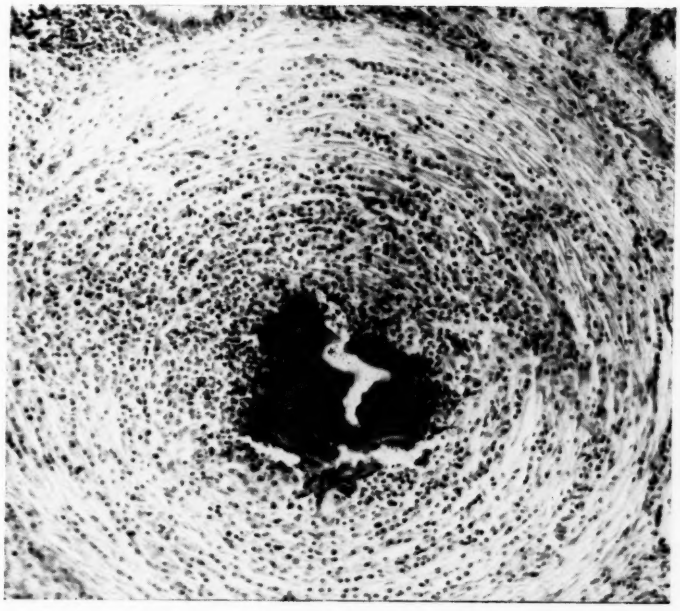

FIG. 1

Lesion of botryomycosis showing the central mass of eosinophylic substance.
H & E x 150

(Article by Blackburn, page 311)

PLATE 2

FIG. 1
The lamb which lived on salt water

(Article by Chesney, page 317)

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MIGRAM IN SHEEP

R. W. L. CHESNEY, M.R.C.V.S.
Minehead.

Summary

Six sheep were kept under observation during eight weeks of a hot dry summer. Three were grazing with the flock, and the other three were confined in pens exposed to the sun. Of the three in pens, one was allowed freshwater and food ad lib.; the second, saltwater and food ad lib.; and the third, freshwater ad lib. and the minimum of food compatible with comfort. A record of their reactions is included; and a possible connection with Migram discussed.

Introduction

The disease ' Migram ' which occurs in sheep on the Romney Marsh, was recorded by Chesney (1953). It was suggested that the possible cause of the " staggers " syndrome might be a dehydration, and this was based on the following data: the disease occurs most commonly when climatic conditions produce a state of dryness in the grass and a reduction in the amount of available fresh water; the symptoms often arise after the continued ingestion of seawater; and the condition disappears gradually when the sheep are allowed access to a plentiful supply of fresh water.

Grazing conditions in this particular area of the Marsh are such that the grass is always kept down to within an inch or two of the ground, and this is effected by continuous grazing or mowing; and so there is rarely any likelihood of the grass seeding. It is possible, however, that plants growing along the slopes of the ditches and a railway embankment may run to seed occasionally, and ergot has been found in small amounts. No other toxic plant, such as St. John's Wort, has been detected on the farm. Literature regarding ' staggers ' in sheep (Lee and Kuchel, 1953), points to the possibility of a cobalt deficiency associated with grazing on the perennial grass, Phalaris tuberosa. But, according to the local authorities, this plant is not found on the Marsh. No tests for cobalt have been carried out on the migram area because the chemists consider that the usual variable results of such tests are unreliable evidence. The fact that sheep recovered from Migram when allowed plenty of fresh water, decided against the possibility of a mineral deficiency.

As far as I know, the only investigations carried out on sheep to determine their reactions to hot dry conditions, have been done under laboratory or sheltered conditions, and not when exposed to direct sunshine. I have not found any record of data relating to sheep which had to live on the bare minimum of food; e.g. the parched grass of hot dry summertime; or any information regarding the requisite amount of drinking water needed under such conditions.

In an attempt to determine the reactions of sheep to such conditions, and bearing in mind the possibility of saltwater in relation to migram outbreaks, observations were made and the results are recorded. These observations were clinical in nature, but every care was taken to measure the food and water. In the case of the latter, a rough check was kept on the daily evaporation, and this approximated to one twelfth of the total daily supply. Weather conditions at the site were recorded by

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means of a dry bulb thermometer exposed to the sun. Records of the relative humidity, hours of sunshine, wind and rainfall measurements were only approximate, and were based on the recordings made at two stations, one to the southwest about four miles distant, and the other two miles northeast. The first station is on the hills and the other at sea-level, and both are protected moderately well from the weather.

Materials

The sheep pens were situated in the open, on the slope of a shallow valley which is approximately 100 feet above sea-level, opening to the northeast and fairly well sheltered. They were exposed to the whole of the day's sunshine. Each pen was about 9 feet by 6 feet. There was no roof, and the floor was earth, free from vegetation. Although the pens were adjacent, there was no chance of any sheep obtaining any of its neighbour's supply of food or water.

The food was meadow hay, free from any ergot contamination, and comprising mainly sweet vernal, bent grass, clover and a variety of occasional grasses. Its water content was in the region of 12.2 per cent. Crushed oats were given also.

Water was obtained from the mains which supplied the local human inhabitants, and was replenished daily.

As it was not convenient to obtain seawater, a 2.0 per cent. solution of common salt was used. This percentage was fixed on the basis of the experience of several workers who had found that 1.5 to 2.0 per cent. was near the danger line for health if given over a period; and also because this percentage was more approximate to that found in the ditches on the migram area.

The animals were six 7 month old Dorset Horn ewe lambs, born on the farm. They were in normal health and condition and, in common with the rest of the flock, had been wormed a month or so previously. They were numbered 1 to 6 respectively, and their weights were recorded. They had been shorn and dipped.

Methods

Lambs 1, 2 and 3 were to be penned and 4, 5 and 6 were to remain with the flock. Lamb No. 1 was to be allowed freshwater, hay and oats ad lib. It was to act as the control, to the penned lambs.

Lamb No. 2 was to be allowed saltwater, hay and oats ad lib.
Lamb No. 3 was to be allowed freshwater ad lib. but its food was to be kept to the bare minimum; the daily amount to vary according to the reactions of the animal.
Lambs No. 4, 5 and 6 were to act as controls.

The period of observation was to last as long as possible during a spell of hot dry weather. Fortunately this spell lasted 8 weeks.

Reactions to Confinement

Except for one brief occasion the lambs did not leave their pens for 36 days. On this occasion, at the end of the third week, they were allowed out for five minutes in order to check any abnormality during stimulated exercise. During their sojourn in

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the pens they showed no desire to get out, and no objection to food and water offered. At no time was there any sign of discomfort or embarrassment, beyond an increased respiratory rate during the heat of the day, which was common to the whole flock.

No. 1 lamb was perfectly content with its diet and settled down to an average intake of 2⅓ lb. of food and 4⅓ lb. of freshwater daily.

No. 2 lamb took to the saltwater without the slightest trouble. On the first day it drank 6¼ lb. and from then on it averaged 9½ lb. daily. Its appetite was amazing, averaging 4½ lb. of food per day. It was always on top of form and ready for food. Whenever the shepherd entered the pen, this lamb invariably embraced him, and at the time we attributed this display to 'cupboard love'. During the first seven days on saltwater, its dung was brown in colour and soft in consistency; but then it became hard and remained like firm marbles for the remainder of its term in the pen.

No. 3 lamb was allowed only 4 oz. of hay per day for the first 17 days, and its average water intake was 5 lb daily. The animal showed no signs of hunger when the day's ration was fed; and often took half a day to finish up all the wisps. It was quite content and appeared normal in every way. So much so, that it was decided to reduce its ration to 2 oz. per day. This was its daily amount for the next 18 days; and during that time its water intake dropped to 3¾ lb. per day. Even then a few wisps of hay were to be seen in the pen at the end of the day.

On the 32nd day the feeding of oats was stopped. This caused no immediate increase in the amount of hay ingested by Nos. 1 or 2; but four days later, when No. 2 was changed over to freshwater, the daily hay intake of that animal rose from 2½ to 3½ lb.

At 7.30 a.m. on the 36th day, lambs 1 and 3 were allowed out of their pens for half an hour's grazing. They were very happy to get at the grass, but No. 3 was certainly not ravenous. At the end of the period they were stimulated to run around, but showed no abnormalities in gait or behaviour. Except for a slight hollowness in the flanks of No. 3, it was not possible to differentiate between them regarding normality of appearance and behaviour. No doubt, sustained exercise would have shown some reaction on the part of No. 3 which had eaten only 6½ lb. of food during the past 36 days. No. 2 lamb had been allowed out to join in the enforced exercise, but no abnormal reactions were noted. An interesting feature of their return to their pens, and one that was noted on the first occasion as well, was the fact that each went straight to its own. Lamb No. 3 was given 8 oz. of hay that day and it ate all of it.

For the next 20 days, lambs 1 and 3 were allowed out at varied times and for increasing periods.

For 10 of these 20 days, No. 2 was confined to its pen with freshwater and hay; a daily average intake of each being 9 lb. and 3½ lb. respectively. On the 47th day, it joined the other two in their daily periods of grazing. Details of this period of transition are given later.

The respiratory rate of all the lambs during the 35 days was recorded at five day intervals and the readings were:

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Lamb	1*st*	5*th*	10*th*	15*th*	20*th*	25*th*	30*th*	35*th day*
1	160	180	160	170	140	120	110	110 rpm
2	160	170	150	170	170	150	130	120
3	160	170	160	160	130	110	110	100
4	160	180	150	170	150	140	130	120
5	160	180	150	170	140	130	120	120
6	160	170	160	170	150	130	120	110

Weather Conditions

1955 *Date*		12.0 *GMT*	12.0 *RH*	*Rain*	*Wind*	*Sun*	*Cloud*	*Comment*
July	17	76°	60%	—	NNE(5)	12.6 hrs.	—	Sunny day
	18	78	82	0.98″	ENE(L)	5.0	" "	8 hrs. thunder rain
	19	84	75	—	NNE(M)	10.0	—	Very hot all day
	20	84	75	—	ESE(M)	8.0	—	" " " "
	21	78	70	—	NNE(M)	8.0	" "	" " " "
	22	80	73	—	Calm	5.0	—	" " " " haze
	23	86	58	—	NNE(VL)	8.0	—	" " " " "
	24	70	90	—	"	1.0	" "	Dull. Mod-heat. Haze
	25	68	78	—	NE(M)	3.0	" "	Cold a.m. Warm p.m.
	26	80	72	—	"	8.0	—	Moderate heat. Dull.
	27	76	68	—	"	12.0	—	Hot day
	28	80	52	—	E(L)	10.0	—	Very hot day
	29	82	80	—	ENE(VL)	4.0	" "	" " "
	30	78	65	—	E(VL)	8.0	—	Very warm day
	31	82	65	—	ENE(VL)	11.0	—	Warm day
Aug.	1	76	75	—	"	3.0	" "	Very close
	2	84	61	Tr.	NNE(L)	11.00	—	Warm day
	3	80	66	—	NNE(M)	8.0	—	" "
	4	76	70	—	Calm	9.0	" "	Moderate heat
	5	66	78	0.01	W(M)	3.0	" "	" " Damp
	6	58	81	—	WNW(L)	3.0	" "	" "
	7	56	80	—	NNW(F)	9.0	" "	Cool. Sun intermittent
	8	60	70	—	N(M)	12.0	—	Warm day
	9	54	99	0.37	Calm	—	" "	Cool. 16 hrs. rain
	10	54	93	0.01	NE(L)	3.0	" "	Cool. Sun intermittent
	11	78	75	—	NNE(M)	3.0	" "	Moderate. Bright p.m.
	12	80	64	0.01	NE(M)	7.0	" "	Very hot p.m.
	13	84	75	0.05	NE(L)	7.0	" "	Hot a.m.
	14	78	71	—	NNE(VL)	10.0	—	Fine day
	15	78	73	—	SW(M)	4.0	—	" "
	16	76	60	—	SSW(F)	10.0	—	" "
	17	78	85	0.25	"	4.0	" "	Fine p.m. Warm
	18	80	86	0.02	SW(L)	0.5	" "	" " "
	19	80	80	0.05	"	4.0	" "	Very warm. Inter-sun
	20	84	80	—	ENE(VL)	3.0	" "	Fine day
	21	90	55	—	"	6.0	—	" " Warm
	22	92	50	—	SSW(M)	8.0	—	" " "
	23	90	62	—	E(VL)	9.0	—	" " "
	24	88	68	—	"	10.0	—	" " "
	25	86	72	—	ENE(VL)	10.0	—	" " "
	26	88	56	—	"	11.0	—	" " "
	27	82	55	—	SE(VL)	11.0	—	" " "
	28	80	75	—	ENE(M)	9.0	—	" " "
	29	78	70	—	Calm	8.0	—	" " "
	30	76	73	—	SW(L)	7.0	—	" " "
	31	76	75	—	N(L)	9.0	—	" " "
Sept.	1	76	65	—	W(L)	4.6	" "	Bright early. Warm
	2	74	67	0.04	SW(STR)	8.3	" "	Inter-sun. Warm
	3	72	75	—	N(M)	6.5	" "	" " "
	4	78	70	0.01	SW(M)	4.7	" "	Fine day. Warm
	5	70	80	0.20	W(M)	5.2	" "	Inter-sun. Fine p.m.
	6	74	62	—	NNE(M)	11.0	—	Fine day
	7	76	59	—	ESE(VL)	11.0	—	" "

Temperature was recorded at the site of experiment—dry bulb in the sun.
Relative humidity (RH) is approximate and was based on a station four miles distant, and another two miles in opposite direction.
General weather was very warm and dry with very little wind and practically no rain.

Comparative Food and Water Intake

Date	Food (lb.) Lamb No. 1	No. 2	No. 3	Water (lb.) No. 1	No. 2	No. 3
July						
17th	1½	1½	¼	3¾	6¼	3
19th	1½	1½	¼	3¾	6¼	3½
19th	1	1½	¼	3¾	5	2
20th	2½	2½	¼	7½	8¾	4
21st	1½	4½	¼	7½	10	5
22nd	2	4	¼	7½	13¾	4
23rd	2¼	5	¼	5	10	3
24th	1½	5	¼	2½	12½	5
25th	2½	5	¼	8¾	10	6
26th	2¾	5¼	¼	5	17½	3¾
27th	2¾	5¼	¼	5	13¾	6¼
28th	3	5½	¼	7½	20	8¾
29th	1½	5	¼	5	12½	2½
30th	3	5½	¼	3¾	13¾	3¾
31st	2¾	5½	¼	5	11¼	3¾
Aug.						
1st	3¼	5	¼	6¼	10	7½
2nd	2	5	¼	7½	11¼	8¾
3rd	2½	4½	⅛	3¾	8¾	3¾
4th	2¾	5	⅛	5	10	3¾
5th	3	4½	⅛	2½	6¼	3¾
6th	3	6	⅛	3¾	8¾	5
7th	3	5½	⅛	5	10	5
8th	2¾	5½	⅛	3¾	8¾	3¾
9th	2¼	5½	⅛	3¾	5	1¼
10th	3	5½	⅛	2½	3¾	5
11th	3	5	⅛	2½	8¾	0
12th	2½	5	⅛	3¾	8¾	2½
13th	3	5½	⅛	1¼	5	2½
14th	2½	5½	⅛	3¾	10	3¾
15th	3	5	⅛	3¾	7½	2½
16th	3	5½	⅛	2½	10	5
17th	3	5½	⅛	2½	7½	2½
18th	* 2	2½	⅛	2½	8¾	2½
19th	2	2	⅛	2½	8¾	5
20th	2	2½	⅛	5	11¼	6¼
21st until Sept. 10th see next table						
Totals	85½	158½	6½	155	340	144¼

(No. 2 was drinking salt water.)

* Crushed oats discontinued.

Transition Stage

Date	Food (lb.) Lamb No. 1	No. 2	No. 3	Water (lb.) (Fresh) No. 1	No. 2	No. 3	Grazing (hrs.) No. 1	No. 2	No. 3
Aug.									
21st	2½	3	½	5	11½	6½	am. ½	nil	am. ½
22nd	2	3½	1	3¾	7½	6½	„ ½	„	„ ½
23rd	2	3	1½	5	7½	5	„ ½	„	„ ½
24th	2	3½	1½	5	11½	3¾	„ 1½	„	„ 1½
25th	1½	3½	2	2½	10	2½	„ 1	„	„ 1
26th	1	3	2	2½	7½	2½	„ 1	„	„ 1
27th	1½	3½	1½	3¾	10	2½	„ 3	„	„ 3
28th	1½	3½	2	2½	6½	3¾	„ 3	„	„ 3
29th	1	3½	1	2½	7½	3¾	pm.4	„	pm.4
30th	½	3½	½	1½	7½	1½	„ 4	„	„ 4
31st	½	3½	0	1½	6½	1½	„ 4	„	„ 4
Sept.									
1st	0	3	0	0	7½	0	„ 4	am. ¼	„ 4
2nd	½	2½	0	0	3¾	0	„ 4	„ ½	„ 4
3rd	0	1½	0	0	2½	0	„ 4	„ ½	„ 4
4th	0	1	0	1½	2½	0	„ 4	„ 2½	„ 4
5th	0	0	0	0	0	0	NT	NT	DT
6th	0	0	0	0	0	0	NT	NT	DT
7th	0	0	0	0	0	0	DT	DT	DT
8th	0	0	0	0	0	0	DT	DT	NT
9th	0	0	0	0	0	0	DT	DT	NT
10th	0	0	0	0	0	0	DT	DT	NT

11th. The three lambs, 1, 2 and 3, and the three at grass, 4, 5 and 6, were weighed, and then all six rejoined the flock.

am. was from 7.30 a.m. onwards.
pm. was from 1.0 p.m. onwards.
NT. was from 5.30 p.m. until 7.30 a.m. next day.
DT. was from 7.30 a.m. until 5.30 p.m.

At the beginning of this transition stage, numbers 1 and 3 received no food before they were allowed out to graze at 7.30 a.m. As soon as they went on to the afternoon periods of grazing for four hours, their appetites next morning were greatly reduced and their intake of hay dropped rapidly. It would seem that 3 to 4 hours grazing is sufficient to satisfy the daily need during the summertime.

Weight Recordings

Lamb	*1st day*	*35th day*	*56th day*	*77th day*
1	90	92	92	98lb.
2	114	120	110	122 „
3	126	120	120	136 „
4	110	114	112	120 „
5	100	102	102	110 „
6	122	122	124	130 „

On this farm it is a recorded fact that lambs at this stage of growth and time of year, invariably increase in weight by about 3 oz. per week, irrespective of the condition of the grazing.

Worm Egg Counts on the 77th Day

Lamb.	*Nematode eggs per gramme.*	*Tapeworm eggs.*	*Coccidia*
1	200	positive	few
2	1000	negative	neg.
3	400	negative	neg.
4	600	positive	neg.
5	2000	negative	few
6	800	negative	few

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Conclusions

Although the number of animals and the methods employed during these observations do not satisfy the postulates of scientific research, I am convinced that the observations have some definite significance.

It is interesting to note that the water intake of lambs No. 1 and 3 were very similar, in spite of the great difference in food intake. Might not No. 3 lamb's water intake be taken as a rough guide to the basic need for lambs when grazing on parched grass during the heat of summer?

The transition stage was very interesting, and I think it indicates that 3 to 4 hours daily grazing on an average 'bite' will satisfy the appetite and thirst of a growing lamb during the summertime.

A general conclusion to be drawn from these observations would appear to be that during the dry heat of summer, sheep are not unduly disturbed by the absence of food, but are dependent on water. If the water happens to be salty then there is a greater intake of fluid and a greater desire for food. Should there be sufficient food to satisfy this salt-conditioned appetite, then the animal gains in weight and improves in condition. It is a debatable point whether this 'salting' of the animal has any influence on temperament, but it is interesting to note that the friendly behaviour of lamb No. 2 towards the shepherd has persisted for several years, and whenever he appears the 'lamb' will leave the flock and rub against him.

On the Romney Marsh, the sheep are accustomed to drinking from the salt water ditches, and probably have a good appetite for food, especially in thirsty weather. This type of weather often coincides with a shortage of food and sometimes a very severe shortage. Could this combination of factors be a predisposing mechanism in the production of the hypersensitivity associated with the disease 'Migram'?

Acknowledgments

I wish to express my indebtedness for the help given by : Messrs. C. H. Archer and K. G. Holman on meteorological matters; Mrs. J. Upham, the shepherd, for his active interest and very able cooperation; and Messrs. Hosegood and Stevinson, the owners of lambs, for their wholehearted support.

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A CLINICAL STUDY OF BOVINE TUBERCULOSIS IN BANFFSHIRE THE PATHOLOGICAL LESIONS PART 1

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This paper on tuberculosis in cattle is presented with some trepidation, firstly because the material was collected more than ten years ago and since then the picture must have altered considerably by the cleaning up of our herds, and secondly in the light of fresh experience some of the statements on occurrence may now appear to be too dogmatic.

However, since the programme for the elimination of tuberculosis from our herds is now far advanced this description of tuberculosis in its rampant days may be of value and interest to newcomers to this field, who never knew the bad old days of flying herds and uncooperative dairymen.

The data reported below were collected over a period of 10 years. In all, 1090 post mortem examinations were made, including 621 abattoir and 469 clinical cases. The data include descriptions of the pathological findings, deductions regarding the mode of dissemination, and comparisons with corresponding data for tuberculosis in man.

Udder

Mastitis is one of the most important clinical manifestations of tuberculosis in cattle.

Udder tuberculosis was found in about 0.4 per cent. of the dairy cow population of Banffshire. This figure agrees with that reported by Davidson (1938) for Staffordshire and by Rabagliati (1937) for the West Riding of Yorkshire. Torrance (1937) found udder tuberculosis in 0.69 per cent. of the cow population examined by him. Allan (1937) reports 0.47 per cent. in Durham County; Medlock (1937) recorded that in 1936 0.67 per cent. of the dairy population in Essex was affected and Jordan (1937) found 0.2 per cent. affected in West Sussex. The average incidence would seem, therefore, to be in the region of 0.5 per cent. of the dairy cow population.

Johnstone (1937) reported that about 72 per cent. of udder cases dealt with in Bedfordshire were found on post mortem examination to have generalised tuberculosis.

There is a well recognised pre-clinical condition in the cow when tubercle bacilli may be excreted in the milk and in abundance without any macroscopic lesions in the udder. These cases can be identified only by laboratory as distinct from clinical examination.

Griffith (1911) performed some interesting experiments on behalf of the Royal Commission on Tuberculosis, when he showed that tubercle bacilli were excreted in the milk of cows and goats after subcutaneous or intravenous inoculation of cultures. In one case a large dose (100 mg.) was injected subcutaneously into a healthy cow, and a series of guineapigs inoculated with milk from this cow developed tuberculosis. The milk was taken after the first week and until her death, in 30 days, from

generalised tuberculosis. The udder of this cow was found to be normal on naked-eye and microscopical examination. In another case a cow, given the same dose of culture, was found to be excreting tubercle bacilli in her milk 24 hours afterwards, and continued to infect guineapigs up to 155 days later. At post mortem examination the udder appeared to be normal. Similar experiments on milch goats confirmed the results obtained with cows. Griffith showed also that when large doses of tubercle bacilli were inoculated subcutaneously into 12 heifers, 6 to 18 months old, tubercle bacilli were recovered from the undeveloped udders of 8 of the animals when they were killed in 62 to 127 days. In 4 of the heifers the organisms were found in such numbers as to suggest multiplication in the milk sinuses.

Titze, quoted by Calmette (1923), showed that after the intravenous injection of tubercle bacilli into a lactating cow the bacilli began to appear in the milk after about 3 weeks, and that they might persist for as long as 144 days without clinical manifestation in the udder. Again, Ishiwara, Moussu, Rabinowitch, Shroeder and Cotton, Escherich, Roger and Garnier, Guillemet, Rappin and others, also quoted by Calmette, have shown that both in man and animals, with apparently normal mammary glands but with positive tuberculin reactions, tubercle bacilli can be recovered from the milk. Of 20 tuberculous women, Kurashige, Mayeyama and Yamada (1912) (Calmette) found tubercle bacilli in the milk of 17 or 85 per cent. In 9 of these, there was no tuberculosis of the mammary gland. At the same time the authors stated that the number of bacilli found in the milk was small (2 to 7 organisms per 5 c.c.)

Although cases in heifers have been recorded by others, tuberculosis of the udder has not been found in the present series in animals under the age of 3 years. The average age of 92 cases examined was approximately 7 years. It occurs clinically as a progressive induration of the mammary tissues, commencing anywhere in the udder but usually above the lactiferous sinus. The lesion gradually extends until the entire udder tissue of the affected quarter is involved. Although, as a rule, tuberculous mastitis is slowly progressive, cases have been observed in which the disease has developed from apparent normality to an advanced stage within a few weeks. It is usual to find only one quarter of the udder affected, generally a hindquarter, but sometimes two or more quarters are affected. The supramammary lymphatic gland is always enlarged.

Primary tuberculosis of the udder has been found only once in Banffshire, which implies that, although infection by the teat canal can and does occur, apparently it does so very rarely. Since the survey described here was made primary tuberculosis of the udder has become much more common as a result of the introduction of tubercle bacilli into the udder by infected teat siphons in udder irrigation, which is now practised extensively in the campaign against other forms of mastitis.

Tuberculous mastitis, therefore, in the absence of outside interference is in practically every case an extension of disease from the thoracic or abdominal cavity, and is seldom found in the absence of pulmonary tuberculosis, the lungs being apparently the primary site of disease in about 28.3 per cent. of the cases.

Many of the cases of udder tuberculosis in the Banffshire series had a history of acute mastitis. It seems likely that when previous inflammatory disease had

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weakened the mammary tissue and the cow had active tuberculous lesions, the environment was then suitable for an extension into the udder, provided that the latter remained capable of milk secretion.

Once the disease is established, the affected part of the quarter feels dense and without elasticity, and the quarter becomes pendulous to an increasing degree. As the disease progresses, more and more tissue becomes involved until ultimately the whole quarter is heavy and as hard as an inflated motor tyre and not unlike a segment of one in shape. The supramammary lymphatic gland becomes palpable, and may become markedly indurated. Atypical cases are sometimes met with, in which the affected quarter is atrophied and feels as if it were full of " shot ".

The usual finding at post mortem examination is simple nodular or diffuse mastitis with small caseating or calcifying areas, and marked enlargement of the corresponding supramammary lymph gland. True cavity formation was encountered in 3 per cent. of cases.

The evidence of post mortem examinations regarding udder and supramammary gland changes is of importance. When macroscopic lesions, even of a very extensive nature, existed in a quarter of the udder the corresponding lymphatic gland was usually only congested and enlarged, and without macroscopic lesions. When macroscopic lesions were found in a supramammary lymph gland, it was common to find the udder macroscopically free from disease. In a small number of cases, lesions in both the gland and the udder were found, but the infection had not been simultaneous in both. In such cases the gland showed old lesions while the udder infection was apparently of recent occurrence.

Since pulmonary infection was present in almost every case of udder tuberculosis it seems logical to assume that the mastitis was due to infection of the blood stream from a lung focus discharging directly into the pulmonary circulation and carried by the blood to the mammary artery, and so into the mammary tissue, where the organisms were arrested by the secretory cells and local lesions developed. The "toxins" produced would be carried by the lymph stream and as a consequence the regional lymphatic gland would become enlarged. Torrance (1937) holds the same opinion. He says that " where on post-mortem examination tuberculosis of the udder exists with enlargement of the supramammary lymphatic gland, or where macroscopic lesions of tubercle are found in the gland with older lesions in the udder, infection of that organ has been haematogenous; the vast majority of cases of tuberculosis (of the udder) fall within this category ".

At first, milk from a tuberculous udder is normal in appearance, but as the disease advances the quantity diminishes, the fat content falls, and the milk becomes more and more serous in character until, eventually, it is almost entirely so, with little or no fat and only cellular elements.

Respiratory Tract

Glands. Tuberculous disease of the respiratory tract of cattle differs in several important features from tuberculous disease of that system in the human subject.

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The bronchial and mediastinal glands are the commonest sites of tuberculosis in cattle, being affected in 970 or 89 per cent. of the cases recorded. These glands receive afferent vessels from the diaphragm, mediastinum, pericardium, ribs, pleura, oesophagus, trachea, thymus, lungs, heart, liver, spleen and pulmonary lymph glands. The frequency of infection, from such a widely dispersed drainage area, can be well understood.

The mediastinal glands, especially, may become extensively affected and severe cases have been known in Banffshire where they have exceeded 7 lb. in weight. Clinically such extensively diseased glands have caused mechanical interference with the oesophagus and rumination and it is common to obtain a history of recurrent tympanites. As a rule the sternal glands are affected when the pleura is diseased and sometimes the intercostal lymph glands also. A very common site of tuberculous adenitis is the retropharyngeal glands, two in number situated about an inch apart, medial to the great cornu of the hyoid bone above the pharynx and between it and the ventral straight muscles of the head. Enlargement of these glands is common. The enlargement being limited by the surrounding structures and the unyielding nature of the bony structures dorsal to them, they increase in size at the expense of the ventral soft structures and cause mechanical obstruction to normal breathing and the animal develops a " snore ". Later, if the disease is allowed to progress, there is interference with deglutition; the animal salivates constantly and loses condition because of its difficulty in swallowing food.

Larynx. Tuberculous disease of the larynx has been one of the rarest conditions met with in this investigation. It was observed in 2 cases only or 0.2 per cent. Ostertag stated that tuberculosis of the larynx was rare and he found it in 0.13 per cent. of his series. In man, disease of the larynx is common and Baldwin *et al.* show laryngeal disease. They expressed the opinion that the continual passage of heavily infected sputum over the mucous membrane of the larynx was the exciting cause in the majority of cases and considered that haematogenous infection occurred much more rarely. Stamp (1944) believes that, in cattle, laryngeal tuberculosis is not infrequent since he had found several cases in a short period, in contrast to the 2 seen in ten years in Banffshire. The difference in incidence of human and bovine laryngeal lesions is probably due to the difference in the character of pulmonary disease in the two species. Usually the disease follows a more rapid and acute course in cattle.

The lesions observed in the Banffshire cases consisted of large nodular caseating masses with numerous small ulcerating areas on the surface of the larynx or papillomatous outgrowths of hypertrophied submucous tissue. In man, apparently, the condition begins as small slit-like erosions, with sinuses burrowing into the submucosa and the formation of small caseous nodules. These may persist in small isolated nodules or the foci may coalesce. Subsequent caseation and necrosis may destroy the vocal cords entirely. In other cases the epiglottis, aryepiglottic fold and the ventricular bands are the seat of a very severe inflammatory reaction; the tissues are greatly thickened and swollen but the mucous surface is free from gross ulceration.

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Submucous caseation may be followed by widespread ulceration and tissue destruction. Occasionally the bovine type of lesion develops. Loss of voice follows laryngeal tuberculosis in man and in cattle.

Trachea. The trachea in cattle is frequently the site of tuberculous lesions. Ostertag found this structure involved in 3 per cent. of his cases. In the Banffshire investigation tuberculous tracheitis was noted in 49, i.e. in about 25 per cent. of all cases of extensive pulmonary disease and in about 5 per cent. of all cases. In man the trachea is not attacked often. This difference in frequency between man and cattle cannot be accounted for by anatomical differences, for the histological structures of these organs are the same in both species, but it could be accounted for by the postural differences. The stance of the bovine animal would allow the sputum to lie along the trachea, whereas in man it would fall by gravity towards the lungs.

In cattle the lesions in the trachea usually take the form of small pea-sized or thin elongated flattish nodules full of thick pus. They are situated nearly always in the mucous lining along the fibro-elastic part which lies on the dorsal aspect and connects the ends of the cartilagenous rings. It may be that this site is involved because the lymph system drains to the small tracheal glands situated along that border of the trachea. Infrequently multiple ulcerations exist scattered widespread over the mucous surface. Usually the lesions situated along the fibro-elastic border are inconspicuous and not easily detectable until they are incised, when they are seen to involve most of the thickness of the mucous membrane. The contents are liquid in almost all cases. In the human subject affected with chronic ulcerative tuberculosis of the lungs, especially where cavity formation has taken place, the mucous membrane of the trachea may be ulcerated. The lesions are numerous, small, superficial, lens shaped and usually very shallow.

Lungs. Tuberculosis of the lungs, except for tuberculous adenitis, appears to be the commonest manifestation of the disease in cattle. The condition is acute in the majority of cases and when clinical symptoms become apparent the disease has become widespread throughout both lungs. Cavitation, on the scale met with in human pulmonary disease, does not appear to occur. Indeed, cavitation is uncommon and when it does occur the cavities are small and sparse and usually enclosed in a firm capsule. Haemoptysis is uncommon. Expectoration of sputum is common. The sputum is thick, yellow, tenaceous material which often contains caseous particles about the size of an oat grain and is rich in tubercle bacilli.

The lesions in the lungs themselves vary greatly in appearance and size, from small greyish or yellowish nodules about the size of a rice grain to caseo-calcareous lesions of the size of a pigeon's egg or sometimes even larger. Macroscopic examination of diseased lungs shows that the lungs are incompletely collapsed and bosses of areas of caseation can be seen on the pleural surface, most frequently along the dorsal aspect. Early lesions appear to select the costal surface of any lobe, frequently the diaphragmatic lobe. As the disease progresses the lesions invade the substance proper and lobes can become almost totally involved.

The lungs showed lesions in 872 cases, 80 per cent. of those examined, and appeared to be primarily affected in 46 per cent. of that total.

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Miliary tuberculosis of the lungs occurred in 112 cases, 10 per cent. of the 1090 cases examined, and was accompanied by generalised miliary tuberculosis in every case. Miliary lesions of the lungs were encountered only in adult animals.

Pulmonary tuberculosis is rarely chronic in cattle. Typically it is an acute condition running its course to a fatal conclusion in a matter of weeks, or in rare cases, months. Miliary disease of the lungs is usually accompanied by extremely widespread dissemination into all organs and viscera. The chronic miliary disease which is sometimes met with in man seems to be rare in cattle.

One aspect of pulmonary disease in cattle, which until recently has received little attention, is the infectivity of the condition to man. Until 1922 only four cases of human pulmonary tuberculosis due to the bovine strain has been recorded. Since then it has become evident that the infection with bovine tubercle by inhalation is not infrequent.

(Part II will be published in October 1959)

REVIEW OF LITERATURE ON CANINE VIRUS HEPATITIS

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Hepatitis contagiosa canis (Canine Virus Hepatitis—C.V.H.) is an infectious disease which can be transmitted from dog to dog (Rubarth, 1947). Rubarth found that material from infected animals could be passed through bacteria proof filters, and had antigenic properties with a capacity for producing specific antibodies. It could not be cultivated on ordinary bacterial media and could not be grown on the choriollantois of the developing chick. He was not able to induce the disease in rabbits, guinea pigs, rats or mice. He found that treatment with sulphonamide preparations had no effect on spontaneous cases of C.V.H. In histological preparations from different organs and in direct smears from such organs or peritoneal fluid Rubarth was unable to observe the virus microscopically. However, he found that its presence could be demonstrated by its pathogenic effect on body tissues. His investigations supported the view that the infectious agent in this disease is a filtrable virus.

The fox encephalitis virus observed by Green *et al.* (1930) seems to be identical with C.V.H. They found that dogs which have recovered from distemper demonstrated no immunity to fox encephalitis virus. In 1934 they reported that the virus of "epizootic fox encephalitis" was pathogenic for coyotes and dogs as well as foxes.

Rubarth (1947) observed that C.V.H. is liable to occur after treatment with tetrachlorethylene for intestinal parasites. This worm remedy appeared to stir up a latent virus infection.

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In his experiments Rubarth found that C.V.H. with cerebral symptoms, showed more moderate liver damage. He believes that damage to the vascular system entails a toxic damage to the nervous substance. Icterus occurs rarely, which is a feature peculiar to the disease. The icteric liver diseases pass through a pre-icteric stage, and in some cases, the absence of icterus in hepatitis is thought to be explained by the death of the patient in the pre-icteric phase at the early stage of the disease. (Satke 1940). Axenfeld & Brass (1943) also consider that non-icteric cases of hepatitis occur and are of the same character as those with icterus.

Most dogs affected by C.V.H. survive the disease. Lucke (1944) attributes the regenerative power shown by the liver in *Hepatitis epidemica* to the fact that the lesion is acute, not repeated, not diffuse, and affects the liver cells, not the stroma or the blood vessels. (Features which are characteristic of C.V.H.) The virus has an affinity for endothelial and liver cells. It is present in tissue and in body fluids and is excreted in the urine. (Hodgman & Larin, 1953). Infection is conveyed by the alimentary tract, but it is also probable that lice may help to transmit the disease (Parry, Larin, Plat 1951). The frozen virus is able to survive for long periods Larin, 1951) and the stability of freeze dried virus is remarkable. Virus, in the form of freeze dried liver, kept in a hermetically sealed penicillin type vial was kept on a laboratory shelf (maximum temp. 22°—25°C.) and exposed to light for 6 years. The virus was then tested for virulence to dogs. All three dogs which were innoculated intraperitoneally developed acute virus hepatitis and one died of the disease. (Larin, 1959.)

The virus is highly resistant to heat. Virus heated at 56°C. for 30 minutes produced fatal disease in a dog inoculated intraperitoneally. A dog inoculated with virus which had been heated at 100°C. for 30 minutes remained normal on inspection but three weeks after inoculation it developed a titre of the complement fixing antibody, showing that after heating for 30 minutes at 100°C. the virus was antigenically active, although it was not known whether it multiplied or not. (Larin, 1959).

The virus is affected by ultra-violet irradiation although the total destruction of infectivity was not achieved by a two hour irradiation. Ultra-violet irradiated virus protected dogs against inoculations with the unexposed virus, gave rise to antibody in inoculated dogs and was antigenically active in the complement fixation reaction. Antigenicity of the virus *in vitro* and *in vivo* was not affected by killing it with 0.1% formaldehyde. (Larin, 1959).

Fastier (1958) carried out experiments to discover the survival time of the virus on concrete, sacking, sawdust, etc. He found that the longest period over which the virus could survive was 11 days. Rapid destruction of infectivity occurred in the absence of water. Immersion of hypodermic needles in boiling water for 5-10 minutes inactivated the virus. Fastier also carried out experiments to test the resistance of the virus to various antiseptics and found that lysol was the most effective of the antiseptics used in kennel disinfection.

From his experiments he concluded that the virus is comparatively rapidly inactivated by a number of chemical and physical agents. These observations suggest

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that extra-corporeal persistance of virus is not an important factor in the repeated appearance of this disease in dog breeding establishments.

Antigenic specificity. Larin (1951) undertook studies on four strains of canine hepatitis virus, two English strains, one Stockholm strain and one Sydney strain. He was able to establish the antigenic similarity of the various strains tested by complement fixation and by *in vivo* immunity tests.

Fastier (1957) was able to confirm the antigenic similarity by his studies of three New Zealand and one British strain of the virus. From a practical view-point this work suggests that vaccines prepared from one or more strains of the virus will produce immunity to all strains of this virus encountered in the field.

Animals susceptible. Rubarth 1947, in his studies on 190 post-mortem cases, over a course of 19 years, found that the disease had shown a distinct increase over the years. He found that the disease does not seem to be limited to either sex or to have any seasonal character, but among the different breeds of dogs there was shown a marked preponderance for terriers. The ages of the dogs that died lay between a few weeks and 13 years, but most cases (36%) occurred within the first 3 months of life.

Larin (1958) in his observations over 7 years, found that canine hepatitis virus causes the acute form of the disease mainly in suckling puppies and young dogs under one year, of both sexes and various breeds. He found that the disease tends to be chronic and mortality from the mild and symptomless forms of canine virus hepatitis is very low and death in such cases is due to the aggravation of hepatitis lesions by other viruses or bacteria. The virus tends to persist in the infected dog throughout life as a latent infection giving rise to recurrent lesions, this results in fluctuating titres of the complement fixing antibody in the blood. From observations made in a number of kennels he concluded that while epidemics of the disease are infrequent, sporadic cases with mainly symptomless infections may occur all the year round.

Clinical Diagnosis. The clinical picture of contagious hepatitis as stated by Rubarth in 1947 can be summarised briefly as follows:

The duration of the disease varies considerably. In some cases the dog dies without the owner having noticed signs of disease, in other instances it may show signs of sickness a few hours before death, but as a rule the symptoms of the disease are manifested for two to four days.

The clinical picture of the disease is primarily dependent on its duration. Cases rapidly proceeding to death show no clinically observable symptoms, or no signs other than convulsions, the more protracted cases show symptoms of varying nature. The commonest and first observed symptom is apathy. The animal withdraws from its comrades and from human beings, often hiding in a quiet dark corner. There is loss of appetite and in many cases intense thirst. Marked and disfiguring subcutaneous

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oedema of the head, neck and ventrally on the trunk are observed on a few occasions. Vomiting and diarrhoea, the latter sometimes of a haemorrhagic character, are common symptoms and the animals show pain by groaning and moaning. At the outset of the disease the body temperature seems to be raised and may reach high values (40-41°C.) Towards the end the temperature falls and some hours before death reaches subnormal values (35-35.5°C.) Occasionally central nervous symptoms appear, taking the form of spasms in the extremities and neck, or paresia in the hind quarters. On a few occasions besides apathy, Rubarth observed blindness. Mucous membranes are usually anaemic sometimes with petchiae in the gingiva. Sometimes the tonsils are swollen and reddened. Reddened and watery eyes not infrequently form part of the picture, and mucous membranes may be slightly jaundiced.

Often the heart's action and respiration are accelerated, and usually on auscultation of the lungs a bubbling râle is heard. On some occasions, during the period of up to a week after the dog had apparently recovered, a diffuse and perfectly opaque central cloudiness is observed on the cornea of one eye. This change proceeds to the surrounding schlera or conjunctivae. After local treatment with cod liver oil, etc., the trouble resolves in a few days.

When the disease occurs in a litter it seems that the largest and liveliest dogs are the first to fall victims to the disease.

When examination of the urine was made, the urinary reaction as ascertained with litmus paper was acid on five occasions, and in two cases neutral. Apart from albuminaria, which was found in all urine samples, the examination of the urine did not yield any results that could give any real assistance in the clinical diagnosis of the disease. Rubarth observed that in cases of C.V.H. the nuclear inclusions were found primarily in the endothelial cells within capillaries, sinusoids and veins, indicating that the infective material is conveyed through hematogenic channels. The cells attacked degenerate and eventually they are destroyed so that the virus is set free and passes into the blood stream.

So that satisfactory clinical diagnosis could be made, Rubarth devised this method. In order to detect the antigenic substance in the serum he used the complement fixation test for the differentiation of canine virus hepatitis from canine distemper taking care that the serum used as antigen had been inactivated by heating for half an hour in a water bath at 56°C. Antigen was always found in the liver showing nuclear inclusions.

Four years later Larin (1951) found that the complement fixing antigen was specificaliy related to the particle of canine virus hepatitis. In 1955 Smith *et al.* described the micro complement fixation reaction. In 1947, Mansi reported the presence of a specific diffusable antigen. He used the plate gel diffusion precipitation test. In 1953 Coffin *et al.* demonstrated that intranuclear inclusions contain high concentrations of viral antigen. Cabasso *et al.* 1954, introduced the use of tissue culture technique in this work.

Immunity. Until recently little was known about the mechanism of immunity in canine virus hepatitis, until Larin (1955) published experimental results and observations made over a period of nine years.

Larin found that residual lesions in the liver of clinically recovered dogs were very pronounced, showing considerable delay in tissue restitution. The tissue also contained infective virus, posing the question of whether the lesions were in fact 'residual'.

Larin observed the eletrophoretic patterns of the serum protein in various puppies, and on circumstantial evidence was able to conclude that the 'residual' liver lesions commonly found in clinically recovered dogs are possibly foci of virus proliferation in the altered milieu where the immune mechanisms appear to be incapable of eliminating the virus. The patterns suggest that the virus is considerably active in tissues of dogs with symptomless infections and also in dogs after convalescence.

Larin carried out further experiments to discover the role of the complement fixing antibody in immunity to the virus. He put forward a hypothesis that the particle of complement fixing antigen is identical with the virus particle and that the antigen is possibly a form of multiplying virus and that the virus is able to survive in an immune host for a considerable period of time.

Low levels of antibody which are undetectable by the complement fixation reaction made immediately after convalescence, are sufficient to arrest proliferation of the virus for some time but not to bar it from the body, so that it would appear that the usual sharp antibody rise two to three weeks after convalescence may represent the dog's reaction to the emergence of active virus.

From other experiments Larin was able to justify the conclusion that pronounced fluctuations in the specific complement fixing reactions of the sera must have been associated with the survival and multiplication of the virus in the body of immune dogs. The emergence of active virus from time to time introduced new concentrations of the virus antigen to the antibody forming system and thereby permitted the booster effect to operate.

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MASTITIS PREVENTION AND THERAPY*

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Investigations and publications on the subject of mastitis have been varied and manifold. Despite advances in diagnostic and therapeutic procedures, mastitis continues to be a serious problem to the owners of livestock. Though the major emphasis is directed toward mastitis in dairy cattle the problem should be recognized as one of paramount importance in all species of livestock. The greatest incidence of mastitis is usually observed in the early phases of post partum lactation at a time when the young are wholly dependent on the mammary secretions for nutrition and disease prevention, as well as the time of highest production for the dairy cow.

What Is Mastitis?

Mastitis as defined medically is an inflammation of the breast or mammary gland.

The term mastitis as employed in this dissertation will refer to clinical mastitis (observable inflammation of the mammary gland) unless designated otherwise.

Though many investigators have designated *Streptococcus agalactiae* as the causative agent of bovine mastitis, the predominant organism isolated may be a staphylococcus. (Krabbenhoft, Adams & Schipper, 1958; Packer, 1947; Schilingman & Manning, 1956). These authors have in general avoided the use of media containing inhibitory agents and they have not relied upon one procedure in obtaining their data. Investigations to determine the genera of organisms present in the bovine mammary gland exhibiting no signs of mastitis have indicated that a very similar bacterial flora existed in non-mastitis glands to that observed in the mammary gland exhibiting clinical mastitis (Krabbenhoft, Adams & Schipper, 1958; Burrows, 1954). Other less numerous reports indicate as causative agents, *Leptospira, Brucella* and *Yeasts.* Thus it could be postulated that the bovine mammary gland may serve as a repository for numerous potential mastitis producing agents, and that their potential mastitis producing qualities may be initiated by the factors of inefficient management procedures, which in general can be classified under trauma and/or stress.

Predisposing Causes of Mastitis

Mastitis may be described as a "do it yourself disease". The necessary tools are all found in the tool box of inefficient management. Though the greater emphasis in this discussion will be on the therapeutic aspects of mastitis, preventive aspects can never be ignored. Prevention in general is nothing more than the exercising of good management procedures and sane dairy practices that are so often ignored or carried out inadequately. The most efficacious therapeutic measures will have little practical value if preventive measures are ignored.

When the mastitis problem herd is encountered, management procedures should be given maximum attention. The milking machine is often the major offender

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(Maffey, 1959). Often the rubber (teat) inflations are cracked, contain milk stone or have lost their elasticity. Two sets of inflations per milking unit, each used on alternate weeks, will increase the life of the inflations and aid in preventing teat injury. When not in use, inflations should be cleaned thoroughly and stored in a cool, dry place.

Pulsators that are dirty will not function properly. Variable pulsation speed counteracts milk " let-down ". When the dairy cow does not let down her milk completely, the teat cups will crawl causing trauma to the teat lining and ultimately mastitis.

The cooperation of the milking machine serviceman can do much to relieve the veterinary surgeon of the time-consuming problem of maintaining the milking machine in maximum operating condition.

Observations of the milking process and general management can do much to eliminate mastitis producing factors. Some factors to be noted are the quantity and quality of bedding used, removal of the milking machine when milk ceases to flow, adequate size of stalls and exposure of the udder to dampness and draughts. In many instances, problem quarters are those that produce less milk or milk out more rapidly than others. Cows possessing such quarters must be observed closely during the milking process and the teat cup removed when the quarter is milked out if mastitis is to be prevented. When production is 7 lb. or less per milking, the milking machine should no longer be employed as these udders milk out very rapidly and are damaged easily.

High door sills and sharp objects, such as barbed wire, pails, stones and broken glass, in the yard and pastures often contribute to the mastitis problem.

We seldom encounter mastitis as a problem in the dairy herd of a " good cowman ".

Though inefficient management in general has been recognized for a long time as the predominant initiating cause of mastitis it has been overshadowed by extensive investigations relating to causative agents, and the search for antibacterial intramammary chemotherapeutic preparations that would compensate for the " management " laxity of the " poor cowman ".

Possibly the reasons for the lack of interest in research on mastitis prevention through management, has been the interval of time required to obtain conclusive publishable data, insufficient funds for " long time " experimentation, and the unspectacular results compared with the glamorized results of chemo-therapeutic research. Most important of all, management cannot be packaged or dispensed with the same ease and monetary satisfaction as chemo-therapeutic products.

Investigations carried out at our station demonstrate that a cooperative programme by dairy specialists, veterinary surgeons, milk inspectors, milking machine salesmen, and dairy farmers can aid in the prevention of mastitis (Schipper & Olson, 1959). The major emphasis was placed on a simple prevention programme as outlined in

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table 1 (Schipper, 1955). The result was a decreased incidence of mastitis and a complete elimination of antibiotics in milk delivered to the milk collection station (table 2).

TABLE 1

Mastitis Prevention Programme

Inheritance (Selection)

Cows with well attached udders
Rapid easy milkers
Avoid excessively large udders

Housing

Provide adequate stall or pen space
Provide adequate high quality bedding
Avoid dampness, cold and draughts
Prevent udder trauma:
„ high door sills
„ rubbish in yards and pasture
„ slippery floors
„ corn stubble or brush pasture
„ driving with dogs
„ flies

Milking

Keep milking machine in optimum operating condition
Have machine checked annually by manufacturer's representative
Follow manufacturer's operating instructions
Remove teat cup when milk ceases to flow
Keep rubber inflation clean and replace twice a year
Never milk with more than two units per operator
Use the strip-cup as a routine
Call your veterinary surgeon immediately upon detecting the first signs of mastitis

TABLE 2

Results of Mastitis Prevention Programme

	Clinical Mastitis	*Antibotics in Bulk Samples*
November	31.1%	8.1
December	15.0%	
January	34.4	5.4
February	43.5	13.5
	Mastitis Meeting with Producers Prevention Programme Presented	
March	7.3	0.0
April	7.3	0.0
May	5.1	0.0

Figures represent percentage of herds having clinical mastitis and percentage of bulk milk samples containing antibiotics before and following presentation of mastitis prevention programme outlined in Table 1.

Therapy

Successful therapy depends on a simple method of early diagnosis. Though many tests have been and are advocated for the diagnosis of mastitis none have proved more efficient for farmers than the strip-cup. The strip-cup should be used by routine at each milking and when mastitis is detected therapy should be initiated immediately.

As an aid in discussing mastitis therapy, a classification of mastitis based on clinical symptomatology is presented. In this discussion, the term "mastitis" is applied to a disease complex characterized by inflammation of the mammary gland without consideration of aetiology, though complete bacteriological examination have been carried out in all instances during field trials.

Mild mastitis—Abnormal secretion exhibiting various quantities of clots, with probable swelling and heat in the affected quarter.

Acute mastitis—Abnormal secretion exhibiting various amounts of clots and/or serosanguineous, purulent or watery secretions. In addition, infected quarters exhibit one or all of cardinal symptoms of inflammation, with body temperature often above normal.

Peracute mastitis—An exhibition of all symptoms described for acute mastitis, but in a more severe form. Anorexia, depression and/or toxaemia are usually present, with body temperature up to 108°F.

Chronic mastitis—Characterized by intermittent flareups exhibiting any of the degrees of severity described above.

Many cases of acute mastitis may be treated successfully by the farmer. This treatment consists of stimulating the cow for milk let-down and then completely milking the infected quarter. This is followed by repeated stimulation and milking out at one-hour intervals. This treatment is superior to all chemotherapeutic preparations available to the layman. In many instances of mild and acute mastitis the condition will be corrected by this procedure within 4 to 6 hours. If, after this time, the condition has not improved, the farmer has but one choice—that is to call his veterinary surgeon. When used by laymen the chemotherapeutic preparations available today may induce a more acute case of mastitis than that already existing. Because of the lack of understanding regarding asepsis, virulent organisms may be infused into the mammary gland. In addition, many of these preparations do not contain effective antibiotic dosage and intramammary penetration is deficient (Schipper, 1955).

Field and laboratory investigations have demonstrated the following armamentarium of therapeutics and regime of therapy to be effective in the treatment of clinical mastitis under field conditions. When a quarter affected with mastitis is encountered, the farmer is instructed to milk the quarter, or a teat cannula is inserted through the teat meatus in order to allow the secretions to be eliminated from the infected gland. When all of the secretions have been removed, 10-20 units of oxytocin is administered intravenously. The administration of oxytocin serves as a means of ejecting or flushing out the abnormal secretions and bacteria within the mammary ducts and ductules. The above procedure thus provides a means of aiding the penetration, throughout the mammary gland, of the therapeutic preparations which may be administered. In many instances of mild and acute mastitis, the administration of oxytocin and draining of the infected quarter alone will provide successful therapy (Schipper, 1953). Investigations have indicated that there is little danger of abortion upon intravenous administration of oxytocin (Schipper, Koshi, Palleson & Petersen, 1954).

Intravenous administration of oxytocin, without first eliminating the mammary secretions, is of little value in mastitis therapy. Intramuscular administration of oxytocin has been found to be of little or no value in evacuating the infected quarter

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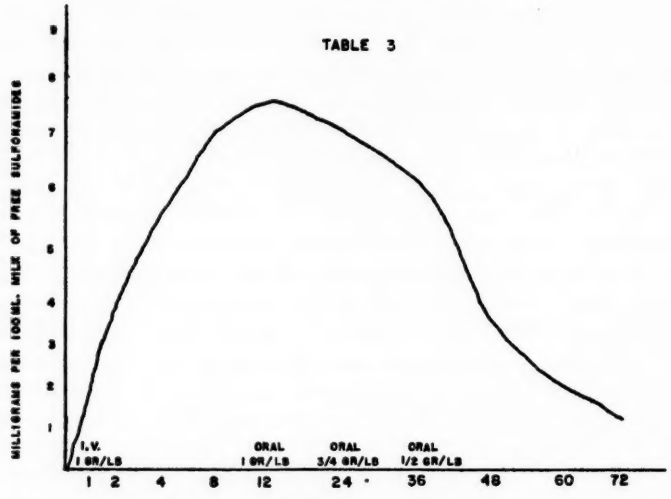
of existing secretions. If the administration of oxytocin appears not to give sufficient evacuation of glandular secretions, a second administration in 10-20 minutes often effects the desired results.

If the infection is acute, additional therapy may be indicated. The intravenous administration of combinations of selected sulphonamides at one grain per pound body weight has proved to provide most effective therapy. Sulphonamides are eliminated in milk in the following decreasing order of concentration upon intravenous and/or oral administration:

Sulphamethazine
Sulphamerazine >Sulphanilamide>Sulphadiazine>Sulphathiazole
Sulphapyridine (Schipper & Eveleth, 1959)

The milking out process at half or hour intervals is valuable additive therapy. If higher levels of sulfonamides are desired over a greater period of time they may be achieved by oral administration of selected combinations of sulphonamides administered at one half to one grain per pound body weight at the time of intravenous administration with additional administrations at twelve hours intervals.

TABLE 3



If the infection is of a peracute nature the addition of intramammary therapy may be indicated. Intramammary administrations are made following removal of secretions and included massive amounts of sterile saline (up to 500 ml.) which serves as a carrier for chemotherapeutic materials (Schipper, 1955). These chemotherapeutic materials include a minimum dosage of 400,000 units crystalline penicillin and 1 gramme streptomycin. The addition of antihistamine to counteract swelling and/or pancreatic enzymes to aid in penetration of antibiotics may be valuable adjuvants to antibiotic therapy. All materials are left in the infected quarter for at least 12 hours and upon removal the milking out procedure at one-half to one hour intervals is initiated. Administration is made with a teat cannula and Simplex intravenous apparatus.

The above intramammary medication has proved valuable as a means of combating chronic mastitis. Greater satisfaction has been achieved if one refrains from milking out for 24 hours. This allows the administered materials greater time for penetration of possible inspissated areas. The administration of intramammary medicaments following the last milking previous to the dry period and without removal until the udder freshens again is often valuable in resolving chronic mastitis.

The milking out process, combined oxytocin and systemic medication has been found adaptable and to give satisfactory results in the therapy of mastitis of sheep and swine.

Though mastitis is frequently a primary infection, it is often associated with such infections and physiopathological conditions as metritis, retained placenta, persistent recumbency, parturient paresis and acetonaemia. When these conditions exist, it is always a good practice to be on the alert for mastitis and to warn the client of the greater possibilities of mastitis than in the normal animal.

TABLE 4

Therapeutic Approach to Clinical Mastitis

	First Signs	Mild	Acute	Peracute	Chronic
Milking out of infected quarter (half hour intervals)	///	///	///	///	
Intravenous administration of oxytocin (10 units)	//	///	///	///	///
Intravenous administration of selected sulfonamides (1 grain/lb. body weight)		/	///	///	
Oral administration of selected sulfonamides (½ grain/lb. body weight)			//	///	
Intramammary administration of sterile saline (50 to 500 ml.) with minimum dosage of 400,000 units cryetaline penicillin and 1 gram streptomycin			/	///	///
plus pancreatic enzymes and antihistamines				///	//

The above outlined procedure of therapy is not advocated as a miracle in mastitis treatment but when correctly applied, it is a most efficacious therapeutic approach. Though prevention has not been emphasized, the encouragement of its application is often very gratifying to the client and veterinary surgeon. Successful prevention and therapy depend greatly on the utmost co-operation by the client. The desired and necessary client co-operation can often be cultivated by the veterinary surgeon's interest and knowledge and mastitis and if he takes the trouble to explain to the client the principles on which his theories are based.

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Discussion

Mastitis is an ever constant problem to the livestock industry. The organisms causing mastitis are usually present within the mammary gland though no clinical signs may be observed. Factors of stress or trauma may trigger the causative agent so that clinical signs of mastitis become manifest. *Streptococcus agalactiae* does not appear to be the predominant organism associated with clinical mastitis. The predisposing causes (stress) of mastitis are factors associated with poor management. When the factors of poor management are corrected mastitis becomes a minor problem for the dairy farmer.

Systemic medication is an effective professional approach to mastitis therapy. The secretions of the infected quarter should be evacuated and this followed by intravenous and/or oral selective sulfonamide medication with concomitant milking out of the infected quarter. The routine use of the strip cup is a very valuable aid to early diagnosis, and competent veterinary service is of paramount importance in the effective control of mastitis.

Summary

Poor management is a common initial or predisposing cause of mastitis. The frequent removal of the secretions from an infected mammary gland is a valuable adjuvant to chemotherapy in the treatment of mastitis. Two of the essentials in a successful mastitis control programme are the dairyman's knowledge of good animal husbandry and his cognizance of the value of veterinary service.

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SHORT-WAVE RADIO THERAPY IN VETERINARY PRACTICE

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In the edition of December 1949 this Journal published an article entitled " Short-Wave Therapy in Veterinary Practice " which I wrote after twelve months' experimental work developing suitable equipment and treatment techniques to satisfy the requirements peculiar to veterinary application.

Even at this time short-wave therapy had been in use for many years by physiotherapists in hospitals and clinics all over the world. It is still one of the principal forms of physical medicine, and nothing has been found to take its place.

This second article is another attempt at stimulating the interest of veterinary surgeons in the treatment. I lay no claim to anything except an interest in the particular problems involved in applying it to veterinary work and their satisfactory solution.

Radio therapy is essentially a heat treatment but, with this very important difference, that heat is *induced* in the tissues, it is not transferred by radiation or conduction, as in the case of infra-red or radiant-heat sources or the homely hot-water bottles and poultices.

The treatment is through the medium of radio-frequency electric currents and for this reason I find it more convenient to refer to it as radio-therapy instead of " Short-Wave " or " Ultra-short Wave ". Before proceeding further I propose to explain the meanings of these terms and their relationship.

The mains electricity supplies in this country provide a current which alternates in its direction of flow through the cables fifty times a second and is referred to as being a " fifty cycle supply "; this indicates the *frequency* with which the *cycle* of alternation occurs every second. The change in direction is not instantaneous, for the current gradually rises from zero to a maximum in one direction and just as gradually returns to zero and commences to flow in the same manner in the opposite direction. The symbol used for this sequence of events (~) illustrates the changes which take place. The mains supply is indicated as " 50 ~ a.c." meaning " fifty cycle alternating current ".

Electric currents of this nature may be generated over a very wide range of frequencies. For example, those which operate a loud-speaker to reproduce the sounds of music and speech may vary between 25 and 12,000 per second or more, while the currents which flow in the aerial systems of radio transmitters extend from below 30,000 cycles per second to hundreds or even thousands of millions. These are the accepted radio frequencies. The prefixes " kilo " and " mega " are used to indicate thousands and millions respectively, so that a frequency of 30,000 cycles per second is referred to as being 30 kilocycles per second (30 kc/s), and 250 megacycles per

second (250 mc/s) indicates a frequency of 250 million. The words " per second " are usually taken as understood and it is acceptable to refer to " 250 megacycles " or " 30 kilocycles ".

The electro-magnetic phenomena associated with radio-frequency currents travel through space at a known velocity, that of the speed of light, which is approximately 300,000 kilometres per second. If the frequency of the alternations or " waves " of energy was one per second it follows that each wave would be 300,000 kilometres long, and since 300,000 kilometres is 300 million metres it is also apparent that waves which occur at a frequency of 300 million a second (300 mc/s) must have a wavelength of one metre. Thus FREQUENCY and WAVELENGTH are related through velocity, so that by dividing the velocity (v) by the frequency (f) we can find the wavelength (λ).

$$\frac{v}{f} = \lambda \quad \text{and} \quad \frac{v}{\lambda} = f$$

The radio-frequency spectrum has been divided into wavebands and their corresponding frequency bands according to the British Standards Institution as follows: —

Waveband	*Metres*			*Frequency Band*	
Myriametric	above	10,000		Very-low	below 30 kc/s.
Kilometric	10,000 to	1,000	Long	Low	30 to 300 kc/s.
Hectometric	1,000 to	100	Medium	Medium	300 to 3,000 kc/s.
Decametric	100 to	10	Short	High	3 to 30 mc/s.
Metric	10 to	1	Ultra Short	Very-High	30 to 300 mc/s.
Decimetric	1 to	0.1		Ultra-High	300 to 3,000 mc/s.
Centimetric	0.1 to	0.01		Super-High	3,000 to 30,000 mc/s.

Until recently most medical equipment has been manufactured to operate at a frequency of 50 mc/s which is equivalent to a wavelength of 6.0 metres and comes well within the ultra-short waveband.

For technical reasons connected with the length of feeder cable that I wished to use between apparatus and patient, the frequency I selected for veterinary work was 30 mc/s (10 metres). Legislation is now being introduced to restrict therapeutic apparatus to operation within a very narrow band of frequencies centred upon 27.12 mc/s (11.1 metres) in order to avoid the possibility of any interference with television and other services.

The principle underlying the application of these currents in medicine is not easy to explain in a few sentences; if, however, I may be forgiven for one or two diversions from strict technical accuracy, it may briefly be described as follows.

The term " alternating " is generally restricted to currents which are generated by rotary machines for purposes of supplying power. Their frequency range is limited, 25 $\sim$ to 1,000 $\sim$ being the extreme. The radio-frequency currents in which we are interested are built up as oscillations in an electrical circuit employing thermionic valves and are therefore known as " oscillatory " currents. Their frequency of

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operation can be maintained within extremely fine limits over prolonged periods and their presence in certain circumstances may give rise to the radiation of energy in the form of electro-magnetic waves with similar characteristics to those of light, and these are in fact a continuation of the spectrum of which light forms a small section.

Such energy radiation occurs from the aerial systems of wireless transmitters and is converted back into radio-frequency currents in receiver aerials over a very wide area. On the one hand we have the currents causing the radiation and on the other the radiation causing the currents: it *induces* the currents in the receiver aerials.

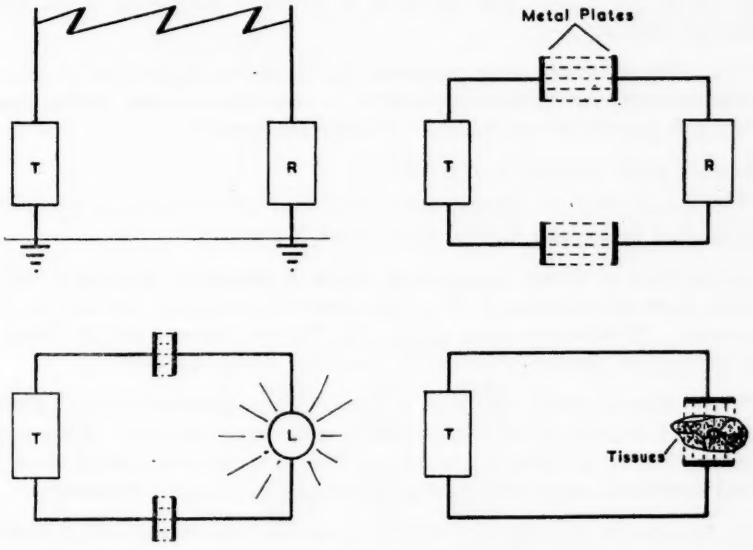

FIG. 1.

Development of the principle from radio transmission and reception to radio therapy is illustrated in the diagrams of Fig. 1. The first diagram shows a transmitter and receiver with their respective aerials, the radiation from one to the other being indicated by a flash. It will be noticed that both transmitter and receiver are connected to earth. In a portable receiver the aerial and earth may be more virtual than actual, but they exist. In the second diagram the aerials and the earth connections have been replaced by metal plates, and the two pieces of equipment brought into closer proximity. The receiver will still operate, transmitted energy passing between the two pairs of plates. If the distance between the plates is still further reduced a lamp may be substituted for the receiver and will be illuminated by the radio-frequency currents flowing through it. The fourth diagram shows the final step. The radio-frequency energy has now been concentrated between the two plates which were substituted for the original aerial and earth of the transmitter, the air space has been preserved, but the lamp and its plates are replaced by animal tissue. In just the same way as the radio-frequency currents induced in the lamp caused the heating of its filament so

will those induced in the various tissue components result in their temperatures being raised. The " field " of energy is confined to the area enclosed by the plates and affects all the tissues in that area, both superficial and deep, simultaneously.

It may be asked why it is necessary to include an air space between the tissues and the plates. The explanation is that currents of this nature tend to flow on the surfaces of the conductors which carry them, and if the plates were connected directly to the tissues they would become a conducting element in themselves, which, quite apart from technical considerations, would defeat the object in view.

This, then, is the principle of Radio or Ultra-short Wave Therapy and at this point I would like to quote from an article by Professor Schliephake in the Journal of Physical Medicine*: —

> ". . . The electrical energy penetrates the innermost depth of the tissues. In contrast with other thermal applications, a regulated molecular motion occurs, which is particularly concentrated on certain structures."

In the same article he goes on to say: —

> " The other prominent characteristic of ultra-short waves is action in depth, which is attained by no other physical agent except X-rays."

In any form of therapy dosage is the factor of paramount importance, and for any given agent the tolerance of the patient towards it must very obviously be taken into account. Of ultra-short wave therapy Dr. Philippe Bauwens and Dr. Bryan O. Scott, writing *The Annals of Physical Medicine* have this to say: —**

> " With thermal agents the object is to raise the temperature so as to promote biological reactions of value in combating pathological processes. These can be summarized as (a) Vascular responses resulting in an increased rate of blood flow and capable of converting a passive congestion into an active hyperaemia.
>
> (b) Acceleration of cellular and biochemical activity in accordance with a modification of van't Hoff's law. Defensive processes are primarily aimed at, but pathological ones are also subordinated to this law.
>
> . . . It is one of the drawbacks of both long and short wave diathermy that no effective means of measuring the temperature in the tissues exists. The operator perforce relies on the patient, whose interpretation of his own sensations and of the instructions and warnings issued can be misleading."

Dosage in the treatment of an animal is simplified, inasmuch as its reactions to discomfort during treatment are not difficult to interpret, and individual tolerances may be determined in this way. Pawing the ground, turning the head towards the site of treatment, raising the limb etc., etc., are sure signs of discomfort during the course of treatment, a definite indication that the threshold of tolerance has been reached and that the intensity of the treatment must be reduced. The almost immediate relief from pain which the treatment affords and the gentle warmth which it promotes in the area will usually result in the complete relaxation of the animal, so that any disturbance of this condition, once it has been reached, can be accepted as proof of discomfort from the treatment.

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I make a practice of carrying out an intensity tolerance test on every patient during the initial treatment by starting at a predetermined high intensity level and noting the time which elapses before signs of discomfort are exhibited. Treatment is then continued at an intensity level reduced by an amount assessed from the time interval. This may not sound very scientific but it has proved to be satisfactory.

Most of my patients have been racehorses, and with the co-operation of trainers and " lads " I have found it possible to give three treatments daily, each of twenty minutes. By this means the hyperaemia initiated by the treatment, which persists for some hours afterwards, is maintained over the greater part of the day. A course of twelve treatments over a period of four days is sufficient for the veterinary surgeon to estimate its effectiveness in any particular case. With these animals it is usually the limbs which suffer damage, and it is my experience that gentle, graduated exercise may be commenced very early in the course (preferably following the early morning session) and this affords a valuable contribution to the re-establishment of the horse's confidence in the affected limb.

The equipment required for administering this treatment consists of (1) an oscillator unit capable of providing sufficient power at the specified frequency, (2) suitable electrodes to function as the metal plates mentioned earlier, and (3) means of connecting them with the oscillator unit. This latter presented the first technical problem to be solved when designing the apparatus.

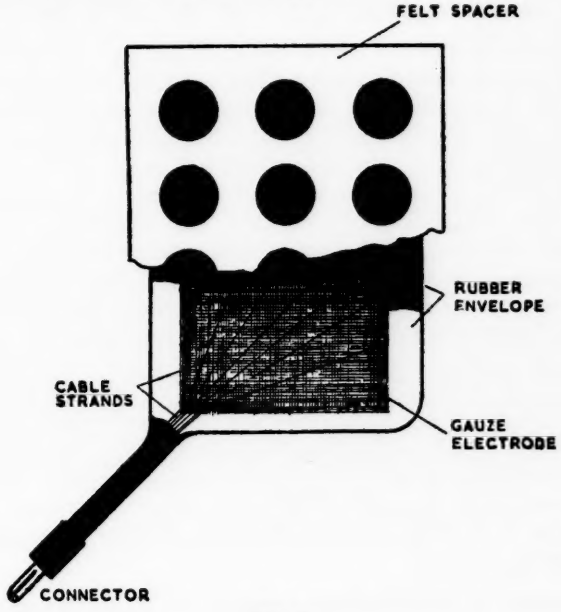

FIG. 2.

To push radio-frequency currents through any random length of wire is impracticable, the problem was solved by using a pair of feeder cables of special construction between the oscillator unit and the patient, and making provision for rapid

disconnection at the patient's end in case of an emergency. This is done by giving the feeders a sharp tug.

The two metal plates and their associated air-space form an electrical condenser, the characteristics of which will be determined by the surface area of the plates. Four sizes cover all the normal requirements, 28 x 18 cms., 18 x 12 cms., 12 x 8 cms., and 8 x 4 cms. are the dimensions which I have found to be most suitable. Fig. 2 shows the construction of these electrodes, which are usually referred to as condenser pads.

The " plates " are made from sheets of fine-mesh phosphor-bronze gauze to which the strands of a short cable are soldered at various points, the other end of the cable being terminated in a connecting plug for attachment to the feeders. The gauze is envoloped in flexible rubber some 3 mm. thick and the minimum air-space required is provided by a pad of perforated felt which is cemented to one of the outer surfaces. To the other surface is cemented a pair of strong tapes which are also stitched to the outer edges of the felt and these provide a means of securing the electrodes to the patient.

By means of extension tapes, and a surcingle to which a number of metal dee's have been attached, it becomes possible to secure the pads firmly to all the usual anatomical regions of the horse which may require treatment. Figs. 3, 4 and 5 illustrate the positioning of the electrode pads; in the last two instances the surcingle and the extension tapes are clearly seen. The pads shown have felt on both surfaces but I have discontinued doing this.

It was realised that in certain animals a localised heating would result in sweating from the surfaces surrounding the treatment area and that during its excretion beads of moisture could be trapped in the hair. If this occurred it appeared conceivable that by virtue of its composition such a droplet might cause a concentration of energy leading to superficial burning. To avoid this risk I used, and still use, absorbent paper tissue under each treatment pad, which not only absorbs the moisture but assists in the preservation of hygienic principles. The beals of sweat coalesce to form a film of moisture in the paper and this, acting as an attenuator, protects the underlying animal tissues from becoming overheated by the energy in the condenser field. An assumption on my part relates the onset of sweating in these circumstances to a critical temperature rise in the deeper tissues as an individual characteristic in the animal.

On removing the pads at the conclusion of a treatment session it is by no means unusual to find that sweating is profuse, the paper tissue being saturated, but without any signs of discomfort from the patient.

Another interesting observation is that as the condition improves under treatment the response is frequently accompanied by a lowering of the intensity tolerance but that the reduction of intensity to a level of comfort does not necessarily reduce the amount of sweating.

The distribution of radio-frequency energy in the tissues undergoing treatment may be regulated to a certain extent by the selection of suitable electrode sizes and their relative disposition about the site of injury, and although it would be incorrect to say that the field of energy can be focussed (at the frequencies with which we are

PLATE 3

FIG. 3

(Article by Denny, page 341)

PLATE 4

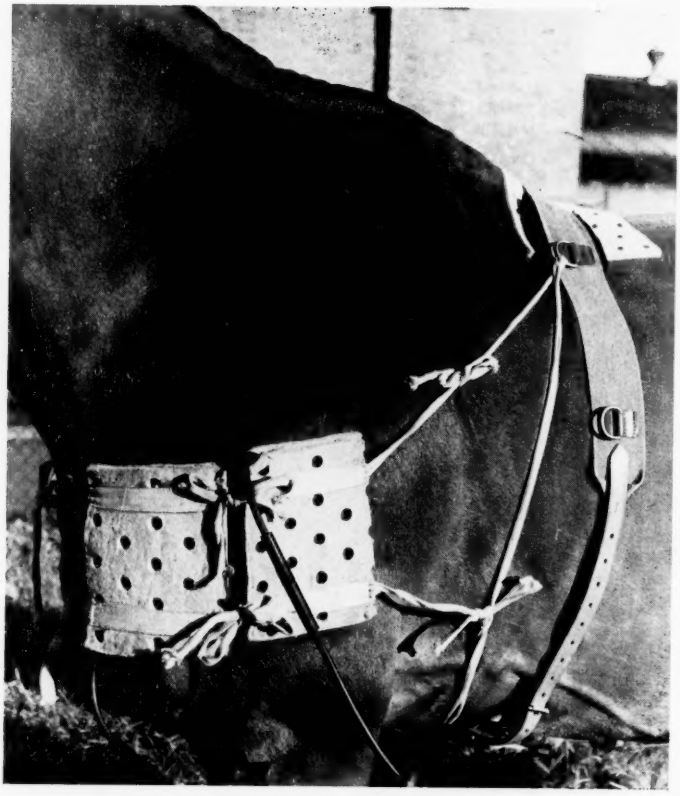

FIG. 4.

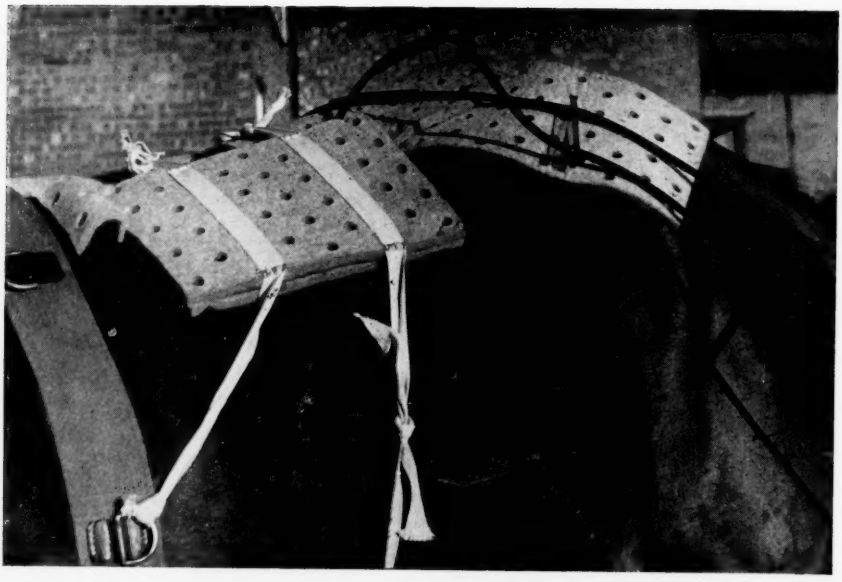

FIG. 5

(Article by Denny Page 341)

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concerned) it is possible to attain a degree of depth concentration by adjustment of the relative air spaces under the two electrodes. This can be done by means of additional felt spacers under the pads.

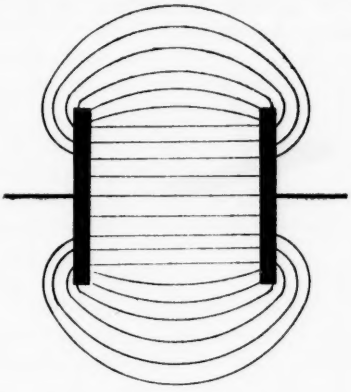

FIG. 6a.

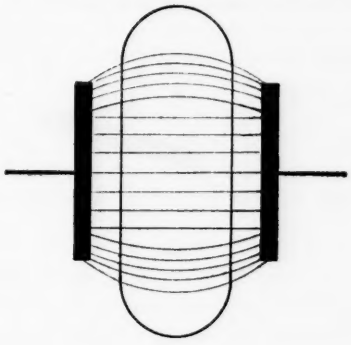

FIG. 6b.

In much the same way as the radio-frequency currents flow on the surfaces of the conductors which carry them they also tend to concentrate on the periphery of the condenser plates, which results in an uneven distribution of energy over their

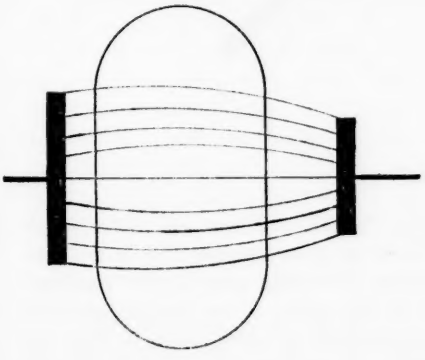

FIG. 7a.

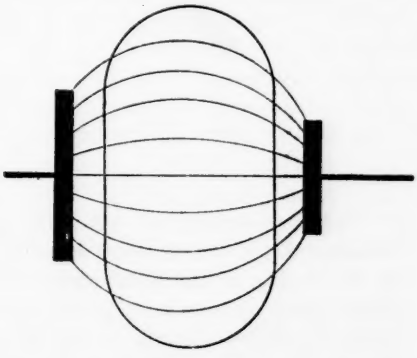

FIG. 7b.

surfaces. This becomes modified to a certain extent by the air-space and the tissues within it. Something akin to refraction takes place at the coincident surfaces of the media, i.e., condenser plate and air-space, air-space and tissues, tending to concentrate the field of energy in the latter. An effect which is accentuated by flexible condenser pads following the contour of the tissues under treatment.

Fig. 6a is a diagram of the energy field as it might exist between two condenser plates separated by an air-space. The thin lines represent the energy field and it will be seen that they concentrate at the edges of the plates. Fig. 6b shows how the

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energy distribution becomes modified when tissues are inserted in the air-space. By using one small condenser pad and one large one, each with equal air-spaces, the distribution might become that shown in Fig. 7a, which is, of course, greatly exaggerated. By increasing the air-space under the smaller electrode the tendancy would be towards a greater depth of concentration, as shown in Fig. 7b.

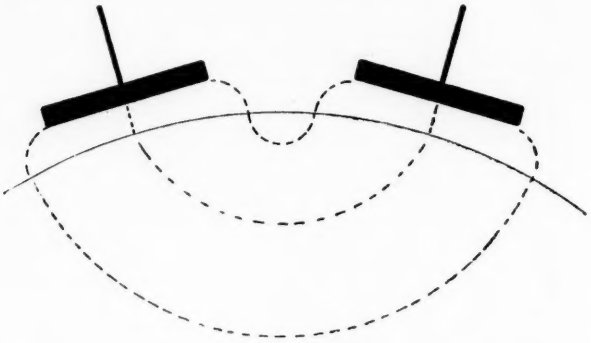

FIG. 8a.

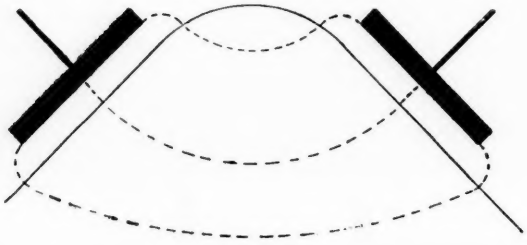

FIG. 8b.

It is not necessary, nor is it always possible, for the condenser pads to be placed on either side of the treatment area. This would be quite impracticable in the case of the shoulder or the spinal region of the horse. In these instances the pads are placed almost on a common plane or nearly at right-angles to one another, and the energy distribution through the tissues will approximate to those shown in Figs. 8a and 8b. In spinal treatment where the mass of tissue has great depth additional spacing will be required under each electrode.

One very important point concerns the securing of electrodes to the patient. Where there is any variation in the air space between electrode and patient there will be a greater concentration of energy at the points of closest proximity. If the flexible electrode pads are not securely attached over such areas the effect will be the same as that for such a flat plate, on the other hand by firm attachment they are usually able to follow the contour of the area. On larger surfaces where the necessity for the use of extension tapes arises it may not be possible to ensure close contact over the obviously desirable positions but in such circumstances it would be most unusual to find

no alternative available which will include the area to be treated in the field of energy between the pads.

The operator is frequently called upon to exercise a certain amount of ingenuity regarding the selection and disposition of the electrode pads as well as to the best means of securing them without interfering with normal movement. Regions like those of the elbow and stifle joints present certain difficulties in that their medial surfaces are inaccessible for this purpose. A treatment pad on the medial surface of the elbow for instance would have to be placed well up in the axilla where much of the energy would be lost to the pectoral muscles; similar conditions exist at the stifle. In such circumstances if the medial pad is placed below the joint and clear of the body and the lateral one as nearly as possible over the joint it will be included in the energy field of the pads. Alternatively they may both be placed laterally above and below the joint.

Although, as I have mentioned before, most of my patients have been horses there have been occasions when I have been called upon to give treatment to smaller animals; needless to say it is absolutely essential to have the patient's confidence and the owner's co-operation in such cases, a snarling dog or a spitting, clawing cat are best left to other methods of treatment.

As an example of technique modification that which I adopted for my smallest patient, a Siamese kitten, is possibly an extreme but it affords an interesting illustration.

The kitten had severely " pulled " the muscles and tendons of a front leg by which it had become suspended after dashing up a heavy curtain. Making friends with it was not too difficult and I succeeded in getting it to relax on one of the largest size electrode pads on my second visit. I had secured one of the smallest pads to my right forearm and held the kitten's paw gently but firmly with my index finger separating its pads and closing the paw over it with my thumb. With my left hand I adjusted the regulator, judging the intensity by the warmth which I could feel in my finger. During the second treatment session I was able to apply gentle traction without any protest from the patient. I made ten daily visits and each session lasted from fifteen to twenty minutes; the last two were extremely difficult as the kitten decided against any further co-operation now that its leg was normal!

There can be no doubt that radio therapy is one form of physical medicine which can be applied with advantage to veterinary practice, especially in relation to the treatment of horses and cattle. In racing stables particularly, where every animal becomes an economic unit, radio-therapy can become a time-saving aid to the natural processes of repair in injuries and other afflictions which form their occupational hazards. I have no experience of cattle but incline to the belief that this treatment could with considerable advantage be applied in their case, not only for injuries but possibly as a controlled stimulant to glandular activity.

Unfortunately my work over these years has had perforce to be a spare time occupation carried on single handed. It was never my intention to become a veterinary physio-therapist but rather to demonstrate and prove that physical medicine

had a place in veterinary practice. However, in the absence of anyone better qualified it was a role which I had to undertake and one which has given me a great deal of satisfaction and enjoyment.

At first sight the cost of an apparatus may seem to be high but in fact it is only slightly more expensive than that which forms part of the regular equipment of a medical physio-therapist. The unit which I have designed for veterinary use has of necessity to be somewhat more robust and is in consequence a little heavier than the portable medical apparatus. Where an equipment is located in one establishment for any length of time it is an advantage to be able to move it around with ease and for this purpose I have designed a trolley fitted with a stowage box for cables and accessories.

Obviously it is to be preferred that the practice of veterinary physical medicine be confined to qualified operators and I would submit, with respect, that those members of the Chartered Society of Physiotherapists who are interested in veterinary work and to whom the study of animal anatomy would present very little difficulty, be admitted to membership of an auxilliary veterinary service registered at the Royal College. This would provide (a) status to the individual, (b) much needed support to the Act of 1948 and (c) assurance to the veterinary surgeons that the work was being carried out efficiently and in accordance with their instructions.

In conclusion I would like to express my gratitude to Professor McCunn for all the help and encouragement he has given me since 1949, the veterinary surgeons who have given me cases for treatment and to Dr. Philippe Bauwens of St. Thomas's Hospital for his guidance and help in matters relating to the technicalities of electro-medical equipment since 1936, also for his permission to quote from his own writings.

To those readers with more than an elementary knowledge of radio theory I present my apologies.

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REVIEWS

PRACTICAL ANIMAL HUSBANDRY. Miller and Robertson, Edinburgh, Oliver and Boyd. 7th Edition. Price 31/6d.

A new edition of Miller and Robertson's Practical Animal Husbandry is to hand. It is the seventh edition of a book which has become a firm favourite with veterinary students in search of a little practical knowledge and a relaxation from the tedium of the modern super scientific curriculum. The form of the book is on previous lines but moving with the times the authors devote more attention to the smaller animals. This departure is of value not only to veterinary students but more particularly it will be of educational value to the workers in laboratories who use small animals in their research efforts. I am sure that these animals will benefit if their masters read the book, for many research workers have little knowledge of the general care of their beasts.

The general principles of goat management are set forth very well.

In the section devoted to cats and their breeding a slip has occurred, the gestation period is 63-65 days, not 56 days.

When discussing the management of bedding of large animals, I am surprised that the authors suggest that the clean portions of a soiled bedding be dried in the sun. Salvage of bedding is an economy measure and if the bedding is dried in the sun it becomes brittle and breaks into small pieces and its value as bedding is destroyed. Straw should be dried in windrows. All the essential factors concerning the management of the domestic animals have been condensed to a reasonable proportion in this book. The layout is good and references are easy. The illustrations are simple in detail, they are plentiful and they must be of great aid to those who seek to improve their knowledge and skill in the art and craft of animal husbandry.

Its title includes the word Practical and the authors can be congratulated in pursuing this view point in a time when the theorists, who often cannot implement their teaching in practice, are on the ascendant.

REPRODUCTION IN DOMESTIC ANIMALS, 1959. Vol. I. by H. H. Cole and P. T. Cupps. New York and London. Academic Press. 651 pages, 143 illustrations and many tables. Price $14.50.

The editors of this text-book are to be congratulated on producing such a sound treatise on the subject of reproduction in domestic animals.

Designed for the requirements of undergraduates, veterinary surgeons and research workers in the field of reproduction, it fulfills its object admirably.

Eighteen authors, all experts in their particular fields, discuss fully in sixteen chapters the anatomy, physiology, embryology and pregnancy of the domestic animals as related to reproduction. There are most comprehensive references at the end of each chapter.

The publishers have produced the book excellently and it is well illustrated. The quality of this book makes one look forward to Vol. II with keen anticipation.

REPORT ON THE ANIMAL HEALTH SERVICES IN GREAT BRITAIN, 1957. H.M.S.O. 6/-.

Foot and Mouth disease followed a similar pattern in 1957 as in the previous year. The greater number of outbreaks occurred during the latter part of the year and over a third of the primary cases were attributed to the spread of infection from the Continent. The incidence of Swine Fever was slightly higher than in 1956 but well below the figures for previous years.

The number of outbreaks of Anthrax was the lowest since 1949: it still appears to be necessary to warn against the dangers inherent in the spilling of blood and of

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cutting suspected carcases as this had taken place in a goodly number of cases. There is apparently a continuous failure on the part of cattle owners to observe the Warble Fly (Dressing of Cattle) order of 1948 as there was an increase in the number of warbled hides reported. There was a slight increase in Swine Fever but the incidence was well below that of recent years.

For the second year in succession there was a rise in the number of outbreaks of Fowl Pest and nearly two-thirds of them occurred in Lancashire.

The eradication of Bovine Tuberculosis continued to make rapid progress during 1957 and by the end of the year about threequarters of all cattle in Great Britain were attested.

The curious phenomenon of finding *Br. melitensis* in cattle in this country with no apparent associated human disease is again brought to our notice. The practice of slaughtering cattle which secrete this organism in the milk was discontinued in 1956; it is recorded that this bacterium was recovered from cattle at nine farms in different parts of the country during 1957. Regular vaccination against contagious abortion with Strain 19 is appreciated by many as a wise precaution even in clean herds.

A committee set up under the Chairmanship of Lord Balfour enquired into conditions whereby cattle were exported to the continent for slaughter. A working party set up by the Council of Western European Union also considered the problem and their recommendations supported very largely those of the Balfour Committee. As a result the conditions in this trade have been improved and the welfare of the cattle safeguarded.

A little over half of the report is given over to accounts of the laboratory, research and investigation services. Mucus agglutination tests are being used in a scheme for the eradication of Brucellosis; work continues on *Vibro foetus* infection and on Johne's disease. An interesting and suggestive observation concerns the importance of subsidiary factors in the latter disease: Johne's disease has occurred in one pair of twins and not in the other on three occasions despite their close association from birth onwards. Tuberculoid mastitis continues to be diagnosed and rapidly growing saprophytic acid-fast bacteria recovered. The mastitis picture shows the change from some years ago; *Strept. agalactiae* declines in importance whilst *Staph. pyogenes* assumes the leading role with a very great variety of other agents especially Gram negative bacteria. A non bacterial though transmissible mastitis occurs and this may be diagnosed only by infecting another cow. Many other interesting observations are made; the precipitin reactions between Swine Fever infected pancreases and immune sera in gel plates should give substantial help to diagnostic procedures. The importance of *E. coli* as a pathogen in pigs and in poultry and the wide variety of Salmonella recovered from birds are recorded. Wild and cage birds are examined and interesting data are given of epidemic tremor in birds, duck virus hepatitis, feather-mite infestation, leptospirosis, myxomatosis and metabolic diseases. The work at the veterinary laboratory at Lasswade is recorded in a separate section as well as the more important studies of the Investigation Service. Examination of blood in cattle within an area of 14 square miles of the Windscale incident showed that pasture contamination was insufficient to cause radiation sickness.

The Reading Cattle Breeding Centre reported the artificial insemination of 49,019 cows and heifers during the year. There are also records of the studies made on the storage of semen and the preliminary work on artificial insemination in pigs.

Thirty-two statistical tables complete the Report; they deal with the incidence of diseases, the numbers of animals imported, the quantities of biological products prepared and the diagnoses made of a variety of conditions.

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The work herewith recorded covers a wide field and is of great interest to the epidemiologist, the bacteriologist and the nutritionist as well as to those versed in the aspects of breeding, helminthology and protozoology. It is an excellent account of the admirable work carried out by those veterinary surgeons who work in the field, in the laboratory and the office.

REPORT OF THE AGRICULTURAL RESEARCH COUNCIL, 1957-58. H.M.S.O. 8/-.

The Council's expenditure during the year was a little over £4 million and its main object is to achieve the best possible co-ordination between the work carried on under its guidance and the needs of agriculture.

Problems concerning the breeding, rearing and feeding of cattle, sheep and pigs are the concern of the Council. Those dealing with the slaughter, handling and processing of the carcases are the responsibility of the Department of Scientific and Industrial Research. The same division is found in other branches of food production and consequently some of the laboratories of the latter are being transferred to the care of the Agricultural Research Council. It is also hoped to establish in the near future a meat research centre.

Research on farm building was undertaken by the Council in 1956 and the Council is also charged with the responsibility for monitoring radio-active fall-out in soil, herbage, farm animals and other food stuffs. A laboratory is to be built for this purpose; a system of sampling has been introduced to give information on the level of strontium 90 in foodstuffs and other biological materials.

Advice has been given and research encouraged on the drift of herbicidal sprays and their possible danger in other crops. The Council is also concerned about the question of the accumulation in soils and pastures of the synthetic oestrogens given to cattle for increased weight gain; the present indications are that they become decomposed by the action of soil micro-organisms.

A series of nine articles, in a form suitable for general reading, is included in this report. The subjects covered are: poultry research, potato research, immunisation of cattle against husk, applied genetics, fertilizer placement which is the method of concentrating fertilizers in pockets or continuous bands close to lines of seeds or rows of crops, control of weeds by chemicals, electronic computers in research statistics, and trace elements in crops and in animals. This is a welcome addition and the articles give an indication of the trend of recent investigations in a particular field and some contain a bibliography of recent work.

Separate reports are given of the work done by the units, institutes and centres which receive support or are maintained by the Council. The subjects concern problems associated with soil, plants, and vegetables, the breeding, physiology and diseases of animals, the dairy industry, agricultural engineering, statistics and radiobiology.

From the report we learn that poultry is the second most important of the agricultural commodities with an output in 1957-58 wirth £204 million; the broiler industry has now reached 50 million birds a year. Fowl paralysis and leucosis dominate the disease picture which cost the industry £10 million in 1954. An interesting story has been told of defects in the interventricular septum of the fowl comparable to the "Hole in the Heart" of man. It is dependable on hereditary factors and is not necessarily fatal for unlike man the fowl is able to develop a compensatory mechanism.

Field trials have been made of the efficacy and the safety of a vaccine prepared from irradiated larvae of *Dictyocaulus viviparus*. The vaccine gives calves a high level of protection against husk and the contamination of pastures is thereby reduced.

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Much of the preliminary work in genetics is done with the fruit fly *Drosophila*. The generation time is 10 days and the offspring produced by each female is in the hundreds. The analysis of the breeding experiments with farm animals under the control of the Council gives valuable information but necessarily on a limited scale. A large number of animals are essential to the applied geneticist and the poultry industry provides a fruitful field. Comparisons made between some three-bred crosses (of Friesian, Jersey and Ayrshire cattle), two-bred crosses and pure breds indicate that in the first lactations the three-breed crosses are superior as judged by yield of milk and of butter fat. It is too early to indicate anything further but the part played by genetic factors in controlling the capacity of animals to synthesise protein for the use of man in such forms as meat, milk and wool is of fundamental importance.

Macro-nutrient elements are present in the animal body in relatively high concentration; the trace elements are equally important and some are essential for certain animal enzyme systems. A manganese deficiency may lend to perosis in chicken, and anaemia may occur in young stock if the mother's milk contains insufficient iron. The growth rate of pigs may be increased by the addition of copper to the diet and swayback in sheep has been controlled by injection of copper. Pining in sheep may be due to the failure of the synthesis of the vitamin B_{12} by microorganisms in the rumen because of an inadequate supply of cobalt. Selenium can protect against degenerative changes brought about by diets low in vitamin E and cystine.

The Foot and Mouth Disease Research Institute at Pirbright is the World Reference laboratory and examines material from all over the world; the work also includes the classification of virus types and subtypes. The agar gel diffusion technique is useful for the examination of viruses from field outbreaks and it demonstrates the presence of large (20 mμ) and small (7 mμ) components in Foot and Mouth Viruses. The large component has a high infectivity rate compared with the small one. Tissue culture experiments show that the virus becomes non-infective on entering the cell although virus multiplication subsequently occurs. The infective material in the virus is probably vibonucleic acid and the distribution of vibonuclease which inactivates it, in cells of different tissue may explain the selectivity of the virus in the disease.

Scrapie in sheep intrigues research workers. There is clearly a breed susceptibility and the disease can be transmitted after the inoculum has been heated at 99.5°C. for eight hours. Furthermore, some of the progency of parents inoculated with infective tissue may develop scrapie.

The report is full of interesting, instructive and stimulating data and it is not possible to do more than summarise briefly some of the valuable work being done for our oldest industry, agriculture.

P. MULLER, DDT, THE INSECTICIDE DICHLORODIPHENYLTRICHLORETHANE AND ITS SIGNIFICANCE. Vol. II, S. W. Simmons, Human and Veterinary Medicine, Birkhäuser Verlag, 1959.

Any substance that is more toxic to insects than to man and the higher animals is bound to be of great importance in studying world health problems. DDT is an excellent example of this, and Birkhäuser have now produced the second volume in a series of three on this compound. Probably there is no insecticide that has received so much attention, and there is none that is used so widely. Although many people have regarded DDT as a panacea for controlling all insect borne diseases, it is now a well established fact that many insects including the housefly have become DDT resistant, and these aspects have been described amply by Dr. Simmons in a section devoted to the use of DDT in human medicine. The other two sections are devoted to General Toxicology (Dr. Hayes) and the Application of DDT to Veterinary Medicine (Dr. Knipling). The volume consists of 570 pages of which 65 are devoted to the veterinary aspects. It is excellently illustrated, and Birkhäuser are to be congratulated on producing an attractive volume.

PLATE 5

Photograph by DAVID C. LAWLER

FIG. 1.

The Royal Veterinary College Riding Club Winning Team at The National Riding Club Competition - June 1959. *Left to Right:*- G. A. Cullen, J. M. K. Heron. J. Thompson. C. C. Lorenzen.

(See News, page 355)

While a volume of this nature is bound to be highly technical there are many facts that are intensely interesting to any reader, particularly those dealing with the international control of insect borne diseases, and its general relation to world health and economy.

According to Knipling, the first important use of DDT in veterinary medicine was made by Wiesmann in 1943 in the control of the house and stable flies. Since then many advances have been made but as in all research the solution of one problem always leads to another, and the control of insect parasites poses many problems for the doctor, the veterinary surgeon and the laboratory worker. We are apt to consider our health problems in isolation and to divide medicine into two great divisions, but consideration of a substance such as DDT emphasises the view that all medicine is comparative, and that the health of man and the higher animals must be considered in relation to each other.

The present volume is an excellent reference book and should be included in all scientific libraries.

JEN-SAL SMALL ANIMAL TOPICS. Vol. 1.

Veterinary medicine and surgery, like its human counterpart, has advanced rapidly in recent years and it is difficult for an ordinary man to keep pace with the spate of literature which is poured upon the profession. Much of this valuable material is of a high scientific or technical character and so full of detail that it is far beyond the comprehension of those who are not working in the particular specific field from which it emanates. The summaries at the end of the articles, if they be phrased in simple language, are the only part which are of use to most men. This statement is not intended to cast aspersions on the wit of the ordinary man who no doubt could profit well by a perusal of the entire MSS if he had the time and opportunity to make a critical study. A good purpose is served when the profession is presented with the basic facts of current information and new discoveries in "digest" form. The usefulness of the presentation is enhanced if the script is illustrated. Good illustrations can be more valuable than words. It would seem that the more enlightened drug houses and commercial firms are conscious of the service that they can render to the ordinary practising members of the profession by making available the latest information in succinct form. Some do this by simple folders others, more ambitious, produce small booklets or periodicals, others dry our ink with a blotter which blazes its message many times a day.

Periodicals such as "Small Animal Topics" are amongst the elite of this information service. It is produced well and it is full of most valuable information to help a practitioner in his daily task. The illustrations, of which there are many, are excellent, chosen well and almost tell the entire story.

Jen-Sal Small Animal Topics is produced by Jensen-Salsbery Laboratories Inc., Kansas City, Missouri, U.S.A.

NEWS

THE ROYAL VETERINARY COLLEGE RIDING CLUB

It is good to know that the cult of the horse still means something to the students in the veterinary schools and that the arts of horsemanship are not completely lost. The Riding Club of the R.V.C. is a manifest token in this regard. This year the Club entered a team to compete in the Riding School competition at the International Horse Show held at the White City. This was the first occasion for such an ambitious

venture. The chosen team of four gave a very good exhibition of their skill and in a class of twelve they were awarded fifth place. Five points only separated the 2nd, 3rd, 4th and 5th prize winners. We congratulate the R.V.C. Riding Club, and praise their initiative and courage in entering upon this venture, and against such vigorous and experienced competition. We hope that the Riding Clubs of the other veterinary schools will be stimulated to emulate the success of the R.V.C.

DEPARTMENT OF ANATOMY, ROYAL (DICK) SCHOOL OF VETERINARY STUDIES

Professor Grahame and his colleagues have been studying the vascular system of various organs for many years. They have made a particular study of the renal vascular system of the domestic animals and they have also been able to study, in a comparative manner, the kidneys of some wild and semi-domesticated beasts. Much of the work has entailed the making of casts of the vascular network and many beautiful specimens have been made. As a result new information has been disclosed and some of the anatomical descriptions which previously had been accepted as fact, have been proved to be in error.

The work has attracted world wide attention particularly in the medical field and Professor Grahame was invited to exhibit some of the work at the British and Canadian Medical Association Congress which was held recently in Edinburgh. The exhibition attracted a great deal of attention and comment and it gained a British Medical Association certificate of Merit, the citation being " For scientific value and originality."

PFIZER LTD.

Mr. F. Goulding (General Pharmaceutical Sales Manager) and Dr. A. M. Brunton (Director of Medical Services) have been appointed directors of Pfizer Ltd.

NOTICE

RAISING OF VETERINARY EXAMINATION FEE

The fee payable for the veterinary examination of a horse before export to Europe will be raised from five shillings (5/-) to one pound (£1), as from 1st September, 1959. The increase is required to make the service self-supporting at present day costs.

This is the effect of an Order made jointly by the Minister of Agriculture, Fisheries and Food and the Secretary of State for Scotland.

Publisher's Notices

THE BRITISH VETERINARY JOURNAL, with which is incorporated THE VETERINARY JOURNAL, is published monthly, and copy for advertisements should be in the hands of the advertisement manager not later than the 20th of the preceding month, if proof is required. Tel.: Temple Bar 3386, 7, 8 & 9.

Letters for the Journal, literary contributions, reports, notices, books for review, exchanges, new instruments or materials, and all matter for publication (except advertisements) should be addressed to the Editor.

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